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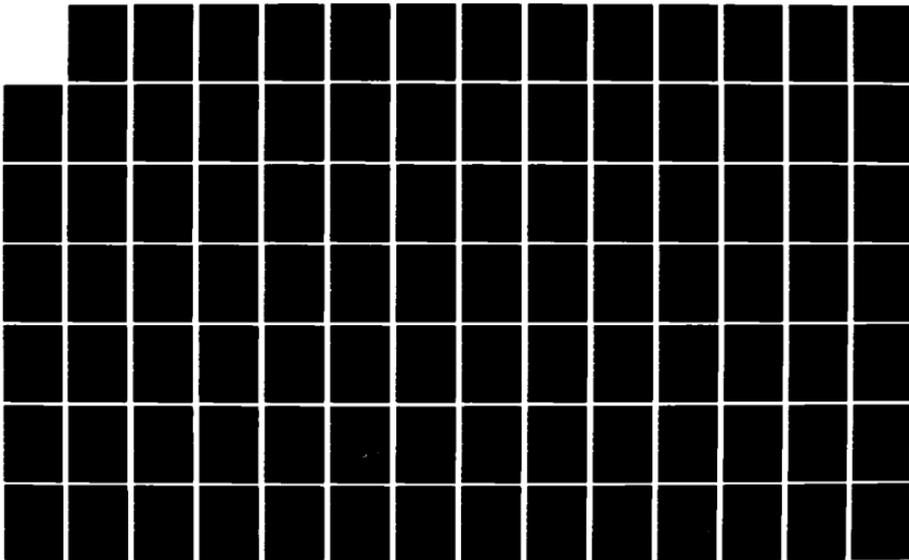
TERREBONNE PARISH-WIDE FORCED DRAINAGE SYSTEM
TERREBONNE PARISH LOUISIANA(U) ARMY ENGINEER DISTRICT
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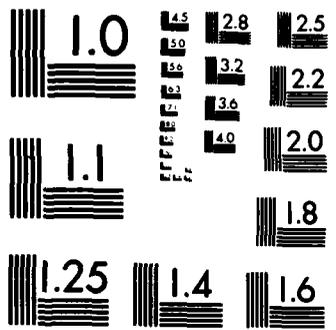
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FINAL

ENVIRONMENTAL IMPACT STATEMENT

**TERREBONNE PARISH-WIDE
FORCED DRAINAGE SYSTEM
TERREBONNE PARISH, LOUISIANA**

**U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA**

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The proposed Terrebonne Parish-wide forced drainage plan was initiated during 1971 in response to flooding problems related to new commercial and industrial development and the demands associated with increased human population, all of which occurred simultaneously in low-lying areas prone to flooding. The preexisting gravity surface-drainage system has proven to be inadequate. Land subsidence and sea level increases have complicated drainage problems.		

20. ABSTRACT

The forced drainage plan consists of 26 proposed and 5 unauthorized projects. The latter projects were begun about the time that Federal wetland permitting procedures were being initiated. All projects were designed to provide controlled drainage for existing and future development along natural levees (the high ground) in the parish. The projects were not designed to protect against major floods but will provide protection against minor floods.

Alternative levee alignments that were considered included: 1) entirely within nonwetland areas; 2) along wetland/nonwetland interfaces; 3) entirely within wetlands; and 4) "no action." Implementation of the "no action" alternative would further stress the existing inadequate drainage facilities.

Between the 31 projects, a collective total of 6 wetland cover types occur: four marsh types (i.e., saline - 3 acs.; brackish - 874 acs.; intermediate - 1,239 acs.; fresh - 3,724 acs.), and two wooded wetland types (i.e., swamp - 2,014 acs.; wet bottomland hardwoods - 5,847 acs.). Within Terrebonne Parish, the 5,840 aggregate acs. of marsh cover types comprise a fraction (1.2 percent) of the 478,463 total acs. of marsh cover types and the 7,861 aggregate acs. of wooded wetlands comprise nearly 7 percent of the 114,568 total acs. of wooded wetlands.

The wetland/nonwetland interface alignment alternative was chosen on the basis of minimal impacts to wetland resources and maximum use of nonwetland space.

Implementation of the wetland/nonwetland alternative would result in improved drainage facilities and would provide protection from minor tidal and backwater flooding of enclosed areas. Other anticipated impacts that would be expected to occur would include: 1) unavoidable and permanent losses of wetland and nonwetland areas and associated functions; 2) isolation of wetland areas; and 3) modifications of turbidity, suspended particulates, sedimentation and other physical and chemical regimes and ecosystem attributes. Additionally, the potential for the release of toxic materials, including heavy metals, also exists.

Cultural resources within the project impact area include 7 prehistoric and 31 historic sites. Implementation of the wetland/nonwetland alignment alternative would not jeopardize any of these resources.

FINAL
ENVIRONMENTAL IMPACT STATEMENT

TERREBONNE PARISH-WIDE FORCED DRAINAGE SYSTEM
TERREBONNE PARISH, LOUISIANA

Responsible Agency: U.S. Army Corps of Engineers, New Orleans District

Action being considered: Issuance of a permit as provided by various sections of the River and Harbor Act of 1899 and Section 404 of the Clean Water Act to the Terrebonne Parish Police Jury, for placement of dredge or fill material into wetlands for construction and operation of a parish-wide forced drainage system.

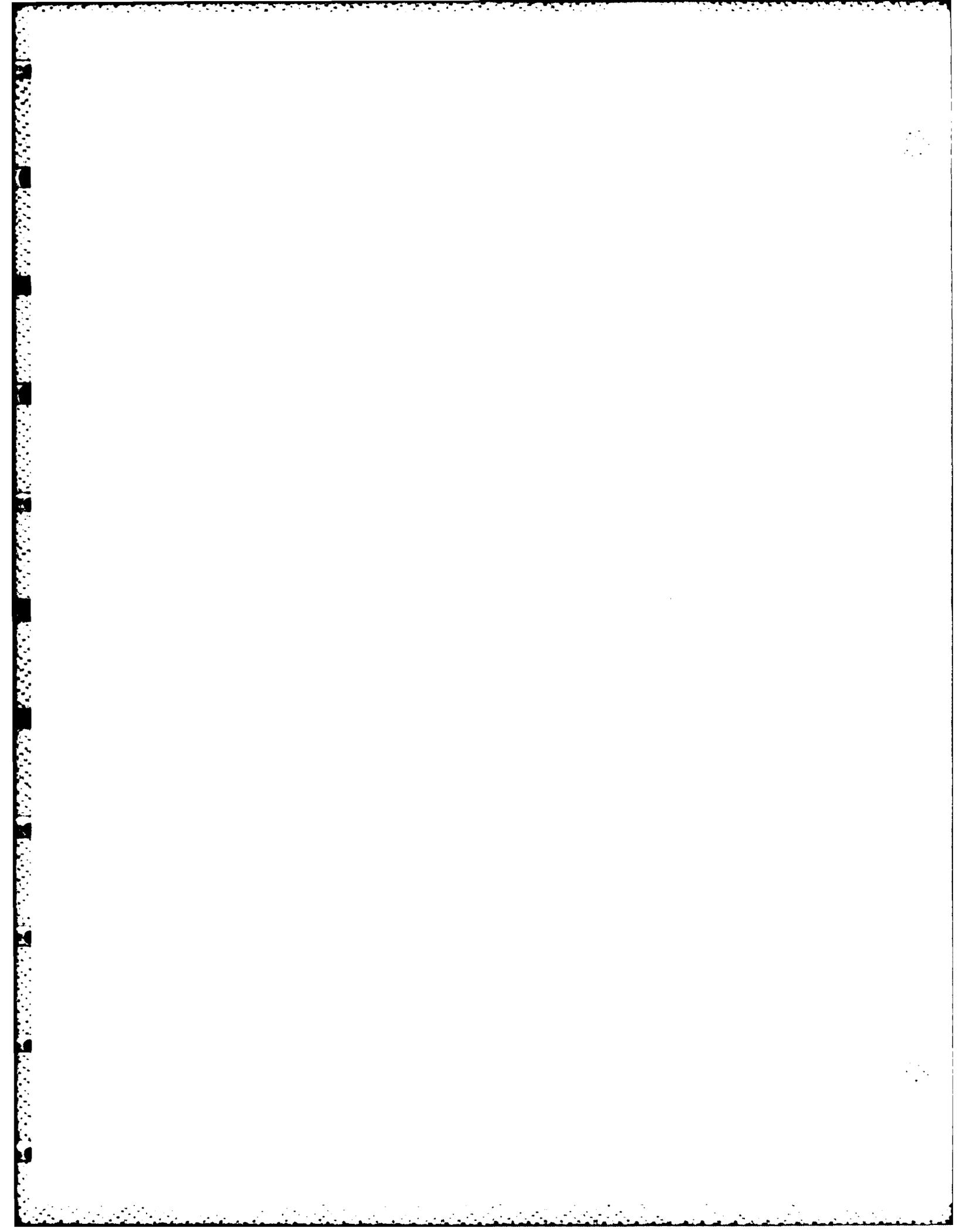
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P.O. Box 60267
New Orleans, Louisiana 70160

Abstract: This Final Environmental Impact Statement has been prepared to evaluate various alternatives for constructing 26 proposed forced drainage projects and consideration of 5 after-the-fact unauthorized projects. The projects are designed to provide controlled drainage to existing and future development along the network of natural levees that accounts for the high ground in the parish. Although the drainage projects will provide some protection against minor flooding, they are not designed to protect against major flood conditions.

Date Comments due:

Responsible Official:

Robert C. Lee, Colonel
District Engineer



Summary

1.0 Introduction to the Project

The proposed Terrebonne Parish forced drainage plan was initiated in 1971 in response to flooding problems that existed in the parish. Increased population coincident with new commercial and industrial development have resulted in invasion of low-lying areas prone to flooding. The existing drainage system based upon gravity flow has proven to be inadequate to accommodate the increased demands. Land subsidence and raised water levels have compounded the drainage problems.

Included in the forced drainage plan are 26 proposed and five unauthorized projects. The latter were begun about the time that permitting procedures were being initiated. The projects are designed to provide controlled drainage to existing and future development along the network of natural levees that accounts for the high ground in the parish. Although the drainage projects will provide some protection against minor flooding, they are not designed to protect against major flood conditions.

The primary regulatory agency is the U.S. Army Corps of Engineers under authority provided by Section 404 of the Clean Water Act. The Environmental Protection Agency has also been given authority to administer certain procedures concerning discharge or dredged or fill material that may adversely affect municipal water supplies, shellfish beds, fishery, wildlife and recreational areas.

Public concerns were addressed through meetings with the private sector and government agencies. Issues were raised at the scoping meeting and categorized into costs, current drainage conditions, effectiveness of proposed projects and priorities for implementation.

Project objectives include provisions for forced drainage construction to areas in the parish with a high incidence of gravity drainage failure, resulting in inundation of developed areas. Objectives include construction of forced drainage projects where needed in all parish-wide developed and undeveloped nonwetland areas. Where significant wetlands are unavoidably encompassed in project areas they will be maintained as wetlands.

The format for this phase of the EIS follows a prepared outline provided by the U.S. Army Corps of Engineers, New Orleans District. This phase should be considered a general statement for the 26 proposed and five unauthorized projects. Permit issuance for proposed and unauthorized projects will be determined on the acceptance of this phase and approval of the follow-up individual project environmental assessments. The 26 proposed projects may be assigned priority at the discretion of the Parish after the 5 unauthorized projects has been satisfactorily resolved.

Alternatives

Alternatives for placing levee alignments were grouped into three categories based upon major environments. These included placement of levee alignments: entirely on non-wetlands; along wetland/non-wetland interface; or in the wetlands. A fourth alternative of "no action" will further stress the poor drainage conditions that presently exist.

Maps in Appendix A (all appendices were published only in the Draft EIS and may be secured from the New Orleans District) are intended to indicate generally project locations. Specific levee alignments have not been determined. These alignments will be part of the individual assessments and permit applications.

Placement of the proposed levees along non-wetland areas would result in less impact from spoil deposition on the wetlands. However, it would alter natural drainage to the adjacent wetlands, and utilize upland space that is in high demand for residential, commercial, industrial and agricultural use.

The wetland/non-wetland interface alternative will result in use of minimal areas of wetlands and less impact than placement entirely in wetlands. Drainage from the uplands to the wetlands would be altered. Wetlands and associated vegetation within the right-of-way would be destroyed. This alternative would provide the maximum amount of upland area to be utilized for development.

The wetland alternative would most severely impact the wetlands. Destruction of wetlands from dredging, spoil deposition and impoundments would adversely affect the area. Interruption of natural drainage and subsidence would be greatest in this environment.

The wetland/non-wetland alignment was chosen on the basis of minimal impacts on wetlands and maximum use of upland space.

Affected Environment

The major habitats and their associated physical, biological, social and economic components comprise interacting natural and man-induced variables affecting the parish. The physical components that form the environmental setting combine to produce a rich flora and fauna resource area. Subtropically located in close proximity to warm Gulf of Mexico waters, the area is influenced by both marine and fresh waters. The parish sits astride at least three abandoned deltaic lobes of the Mississippi River. Its western part is presently subjected to influences from Atchafalaya River water that is forming a new delta in Atchafalaya Bay.

Topological differences, although subtle, significantly influence species assemblages that inhabit environmental niches. Natural levees of former Mississippi River distributaries form the high ground for settlement. The levees radiate out from Thibodaux and Houma forming fingers of uplands that extend gulfward. The levees are wider and higher (+ 10 ft. above NVGD) inland and gulfward they narrow and decrease in elevation to sea level. The general natural levee slope is about 0.7 ft. per mile. Marsh lands, swamplands and water bodies fill the inter-levee basins.

Compaction of the unconsolidated sediments and water level rise cause the parish to experience subsidence. Limited data sources show that the northern part of the parish where most of the forced drainage projects are located is presently subsiding at a rate of about one foot (30 cm) per 50 years (Watson 1981). In addition, factors such as possible eustatic sea level rise and the elongation of the Atchafalaya River system are contributing to additional raised water levels in respect to the land. Local subsidence also occurs where loading is placed on substrate organic deposits. Submergence constitutes a long-term hazard to residents of the parish. It is suggested that an estimated subsidence rate be incorporated

into the planning phase as a factor on the expected longevity of each project.

The parish lies within the region constructed by the Teche Mississippi and Lafourche Mississippi delta complexes. Evidence indicates that the Teche Mississippi was active in the Terrebonne Parish area about 5,500 years ago. Bayou Black is considered to be located in a former Teche channel. Borings through Bayou Black levees near Gibson, Louisiana show Bayou Lafourche deposits at the surface capping Red River deposits, in turn overlying Teche Mississippi levees. There are five sequences of sedimentation associated with the Lafourche Mississippi River system. The sequence began in the earliest Bayou Terrebonne era (about 3,500 years ago) and ended with the latest Bayou Lafourche era (about 300 years ago). Bayou Lafourche was artificially closed in 1903-04.

Diversion of Mississippi River water and sediments from the Lafourche deltaic area resulted in the onset of destruction processes. Subsidence continues, erosion is initiated and salt water intrusion begins to invade inland. The barrier islands fronting the parish form, and are nourished by wave attack on deltaic marshlands exposed to the gulf. Lack of new beach nourishment from riverborne sediments allows the barrier islands to continue to retreat and diminish in size. At the present time land loss in the barrier islands and marshlands is occurring at accelerated rates. Causes are attributed to both natural and man-made processes.

Hydrological characterization of Terrebonne Parish was determined by functional habitats. The study procedure included a literature search and analysis of selected data sets. Physical parameters included water level, salinity, precipitation, evaporation and air temperature. The crucial parameter to overall water balance in hydrologic studies is flow or discharge through water courses that affect the basin. Data deficiencies exist in gauging major bayous and canals in the upper part of the basin and tide measurements in the lower portion. The upper part of the basin is subject to seasonal flooding from rainfall and Atchafalaya River high water. The lower basin south of the Gulf Intracoastal Waterway is subject to a periodic inundation by Gulf waters driven by hurricanes and tropical storms. The absence of meteorological monitoring stations in the latter area limits basin-wide interpretations from data derived in the upper basin.

An aspect of the hydrological study included a long-term hydro-climatological analysis of the basin with particular emphasis upon identifying hydrologic hazards which impact the parish and the forced drainage units. A water balance model was employed to generate flows within the basin and tidal data measured along the coast was also analyzed and combined with the flow data in order to identify combined hydrologic effects. The analysis indicated that three separate but often combined hydrologic inputs create potential hazards for the parish. These include locally generated rainfall excess that frequently combines with high Gulf tides or back water flooding from the Atchafalaya River that result in high water and drainage problems in the parish. Continued subsidence will likely increase the severity of drainage conditions in the parish.

To facilitate interpretation of impacts caused from poor drainage a hydrologic hazard index was compiled that provides monthly and seasonal average water levels for the Houma area. The monthly score reveals hydrologic hazard peaks in April and September. The spring hazard peak results from the combined effects of Gulf tides, back water flooding, upper basin runoff, and locally generated surplus. The fall hazard peak is less complex and mainly results from raised Gulf levels at this time of year.

The greatest danger during high Gulf levels in the fall occurs when associated with low frequency but often severe tropical storms and hurricanes.

Rainfall associated with the fall hazard peak is generally not aggravated by upper basin runoff and Atchafalaya backwater effects. The greatest potential for extreme local runoff results from degrading tropical storms, which sometime stall over the coastline, dumping unprecedented rainfall totals.

There are only three acres of saline marsh lying within the proposed project areas. There are however extensive areas of saline marsh bordering projects 4-3C and 5-4. Projects 4-3B, 8-1 (unauthorized) and 3-2 (unauthorized) lie just to the north of saline marsh and may impact this habitat type. Overall, saline marsh excluding associated water bodies encompasses 120,220 acres or 8.9 percent of Terrebonne Parish (Wicker et al. 1980).

The major emergent macrophytes of the saline marsh are Spartina alterniflora, Distichlis spicata, Juncus roemerianus and Spartina patens. Species diversity is low, a factor attributed to the stressing influence of salt water.

The saline marsh in general supports fauna similar to the other wetland habitats except in lower densities. This is true for such mammals as raccoons, opossum and rabbits and for reptiles such as the alligator, and for many species of waterfowl.

The aquatic environment of the saline marsh is an important nursery ground for commercial gulf menhaden, shrimp and blue crabs. Oyster production is an important industry in the saline marshes of Terrebonne Parish. Salt marsh primary productivity is high and primarily takes the form of vascular vegetation. Spartina alterniflora is the most common salt marsh plant in the project area with a 68 percent occurrence.

De la Cruz (1979) described the energy flow of a salt marsh following a Y-shaped pathway resulting from a grazing food chain (GFC) and a detritus food chain (DFC). The energy flow in a salt marsh is more constant throughout the year since detritus is produced continually, allowing development of an extensive food web with many types of primary and secondary consumers.

Major revenues associated with the saline marsh are derived from resource harvests which include: (1) mineral extraction; (2) commercial trapping and fishing and (3) recreational fishing and hunting. Other economic values of the saline marsh are realized in the form of cost savings such as its ability to absorb storm energy, thereby reducing the need for structural controls.

There are 874 acres of brackish marsh within the project areas. Project 8-1 (unauthorized) contains 760 acres and Projects 3-2 (unauthorized), 4-2B and 4-3C contain the remaining 114 acres. Additional extensive areas of brackish marsh border the above project areas. Overall Terrebonne Parish contains 122,315 acres of brackish marsh excluding open water bodies, or approximately 9.1 percent of Terrebonne Parish (Wicker et al. 1980). Options for maintaining brackish marsh within unauthorized project areas as well as proposed project areas will be detailed in the individual assessments.

Brackish marshes are generally associated with high land loss rates (Wicker et al. 1980). The area of brackish marsh and associated water bodies in Terrebonne Parish has experienced a net increase from 1968-1978 at the expense of intermediate and fresh marshes, which offsets the decrease in brackish marsh to saline marsh. Once the fresher marshes are converted to more brackish conditions the transformation from marsh to open water is fairly rapid.

The major emergent macrophytes of the brackish marshes in Terrebonne Parish are Spartina patens and Distichlis spicata. Species diversity is greater than in the salt marsh but lower than fresh or intermediate marsh. The brackish marsh has the greatest live biomass of any marsh type. Estimated net primary production per square meter for brackish marsh habitat in Louisiana is 2,756 g/m²/yr.

The brackish marsh habitat is the most saline area in which amphibians occur in appreciable numbers. Muskrats are most abundant in brackish marshes. The marshes also serve as important nursery grounds for sport and commercial species.

The dominant energy flow pathway for brackish marsh water bodies goes from the emergent macrophytes to the upper trophic levels via detritus washed into the estuaries.

The brackish marsh area is subject to tidal effects with a net downstream flow. However, the inland movement of water serves to determine the kinds of marsh vegetation, aids in recirculating nutrients and allows the inland migration of larval forms of estuarine species, many of which are incapable of swimming upstream.

Some 1,239 acres of intermediate marsh are located within the proposed and unauthorized project areas. Projects 8-2D (unauthorized) and 3-2 (unauthorized) contain most of the intermediate marsh with 484 and 412 acres respectively. Project 8-1 (unauthorized) contains 185 acres, 136 acres are located within Project 4-2B, 12 acres in Project 8-2E and 10 acres in Project 3-3. Overall, intermediate marsh excluding associated water bodies comprises 56,318 acres or approximately 4.2 percent of the parish area (Wicker et al. 1980). Options for maintaining intermediate marsh within unauthorized project areas as well as project areas will be detailed in the individual assessments.

Species that dominate the intermediate marsh are a mix of fresh and brackish marsh plants. Spartina patens is dominant in terms of spatial extent and production. Plants which normally attain their greatest abundance in Terrebonne Parish intermediate marshes include: Acnida cuspidata, Bacopa monnieri, Leptochloa facicularis, Paspalum vaginatum and Pluchea camphorata. Primary productivity of intermediate marsh has been estimated at 2,800 g/m²/yr.

The intermediate marsh habitat supports a transitional community of organisms which includes both marine and freshwater forms. Intermediate marshes are preferred feeding grounds for herbivorous waterfowl including the dabbling ducks which are prized by hunters.

Alligators prefer this marsh type, which produces an alligator population with almost twice the density of other marsh types.

There are 2,976 acres of freshwater marsh distributed within eight of the project areas. Most of the freshwater marsh is located within the unauthorized projects, as Project 4-1 contains 1,485 acres and Project 3-2 contains 779 acres. Proposed project 4-2B also contains a substantial amount of this habitat, with 520 acres. Options for maintaining fresh marsh within unauthorized project areas as well as proposed project areas will be detailed in the individual assessments.

Significant areas of fresh shrub habitat are found within Projects 8-1 (unauthorized, 342 acres), 4-1 (unauthorized, 154 acres), 4-2B (137 acres) and 8-2A (115 acres).

Inclusive of fresh shrub wetlands there are 3,724 acres of fresh marsh habitat within project areas.

Despite losing some 126,539 acres of fresh marsh since 1955 (Wicker et al. 1980), Terrebonne Parish still contains one of the largest continuous expanses of coastal freshwater marsh in the state and nation. At present, Terrebonne Parish contains some 179,610 acres of freshwater marsh plus an additional 8,924 acres of fresh shrub wetlands. The combined acreage of freshwater shrub and marsh wetlands constitute 14 percent of the parish area.

Fresh marsh contains the highest diversity of plant species. Species dominance can change seasonally as the fresh marsh contains a large number of annuals in addition to perennials. Dominant plants include Panicum hemitomon, Eleocharis spp., Sagittaria falcata and Hydrocotyle umbellata. An estimate of net primary production for fresh marshes in Louisiana based on the measured productivity of selected plants is 2,200 g/m²/yr.

Insects are probably the most important group of grazers in the fresh marsh while the nutria is the most significant and abundant large herbivore in the fresh marsh system.

Predatory insects and spiders, reptiles and amphibians, insectivorous and raptorial birds and predatory mammals compose the higher trophic level.

Water bodies within a freshmarsh system act as conduits transporting material to more downstream areas. Export of these materials represents an important source of raw materials to the lower estuary. The major pulse of these materials coincides with the time of high detrital formation and arrival of migrant species which enter the estuarine area for growth and spawning purposes.

There are 2,014 acres of swamp distributed within 18 of the project areas. Proposed project 1-1B contains the largest expanse of this habitat with 547 acres. Other projects that contain considerable areas of swamp include 4-1 (unauthorized) with 494 acres; 4-2B with 326 acres and 8-2D (unauthorized) with 136 acres. Within Terrebonne Parish there are 94,225 acres of this swamp type which represents 7.0 percent of the total parish land and water area (Wicker et al. 1980). Options for maintaining swamp within unauthorized project areas as well as proposed project areas will be detailed in the individual assessments.

Major overstory swamp species include Nyssa aquatica, Taxodium distichum, Acer rubrum var. drummondii, and Fraxinus pennsylvanica.

Conner and Day (1976) reported a total production of 1140 g wt./m²yr. for a Lac Des Allemands cypress-tupelo swamp.

Carnivores in the wetland portion of the swamp forest system include spiders, voracious insects, reptiles, mammals, insectivorous birds and raptorial birds. Reptiles and amphibians are represented by more species in the swamp forest than in any other wetland sub-unit.

There are 5,847 acres of wet bottomland hardwood forest distributed within 22 of the project areas. Projects containing 500 or more acres as proposed include: 1-1B (1,651 acres), 1-1A (688 acres), 2-1B (610 acres) and, 6-1B (533 acres).

Due to the "high" elevations bottomland hardwoods occupy, most have been lost due to clearing for agricultural or urbanization. Remaining areas are largely confined to narrow linear transition zones between the swamp forest and agricultural areas. Portions of Marmande Ridge, Bayou Mauvais Bois and other small isolated areas still contain some mixed hardwood habitat that is not bordered by a non-related habitat. These areas serve as important wildlife refuge areas during high water level conditions. As of 1978, only 20,343 acres of bottomland hardwood forest remained in the parish (Wicker et al. 1980) and 28.7 percent of those hardwoods lie within the proposed and unauthorized project areas.

Dominant bottomland hardwood tree species in the project area are Ulmus americana, Liquidambar styraciflua, Celtis laevigata and Acer rubrum var. drummondii.

Dickson (1978) conducted a year-round census to determine bird populations within a south central Louisiana bottomland hardwoods. Wood ducks nest in wooded swamps and seasonally flooded bottomland hardwood forests. Another popular game bird, the American Woodcock, also winters in bottomland hardwood habitats.

The white-tailed deer and black bear are two big game mammals which inhabit bottomland hardwoods.

Small game mammals inhabiting bottomland hardwoods include the swamp rabbit, eastern cottontail, grey squirrel, fox squirrel, raccoon and Virginia opossum.

Many species of fish utilize bottomland hardwoods during inundation.

Dry bottomland hardwood forest is virtually non-existent in Terrebonne Parish as the highest elevations along the natural levee ridges were among the first areas cleared and settled. This habitat, therefore, has been converted to other upland areas.

Other upland areas are largely restricted to and include most of the natural levee area in the parish. It represents the largest area within the projects, comprising a total of 33,594 acres which is 69.3 percent of the total proposed and unauthorized project areas.

Natural volunteer grasses on the levee ridges are bermuda grass, dallis grass, johnson grass, bluestem, vasey grass, carpet grass and St. Augustine grass. St. Augustine grass is the major residential lawn cover throughout the parish. Residents plant many ornamental shrubs and trees for aesthetic purposes. Some of the more common native tree species found in residential landscapes are live oak, baldcypress, water oak, pecan, hackberry, American elm, American holly and sycamore.

Many areas of natural ridges are utilized for agricultural crops such as soybeans and sugarcane and as pasture for cattle production.

Pastures, fields and residential lawns and developments provide a diversity of habitats which supports game and non-game wildlife.

Maintenance of this artificial state requires large energy inputs in addition to sunlight in the form of cultivation, fertilizer, pesticides, herbicides, harvesting and crop preparation and transport.

Urban areas also have additional energy and material requirements and produce wastes.

Land use in Terrebonne Parish began with prehistoric Indian occupation and continued through exploration and settlement by Europeans to present practices. In 1978 Terrebonne Parish consisted of 1,347,126 acres of land of which about 52 percent constitutes land and 48 percent water. About 88 percent of the land is undeveloped and 12 percent developed. Most of the undeveloped land consists of wetlands (marshlands and swamplands).

Land use patterns have developed through occupation by diverse peoples ranging from prehistoric Indians to European settlers. Prehistoric Indians were likely part time agriculturists in conjunction with subsistence pursuits.

European settlers arrived in the early 18th century and settled along the bayous in the northern part of the parish. They adopted crops such as corn and squash from the Indians. Crops like rice and indigo were brought from Europe and sugar cane was introduced from the West Indies. Plantation agriculture developed with cotton the major crop which gave way first to indigo and then to sugar cane.

Commercial fishing began in the first quarter of the 20th century and expanded until petroleum activities dominated the area. This resulted in the construction of the Houma Navigation Canal and expansion of commercial and industrial activities associated with petroleum production. These developments resulted in rapid population increases and all activities are vying for space along the restricted natural levees.

Cultural features in the parish include both prehistoric and historic sites, buildings and structures. The cultural resource survey for the parish included an archival map and literature search of recorded prehistoric and historic sites that would be impacted by the 31 forced drainage projects. No field investigations were conducted. The National Register of Historic Places was checked for site listings. This included sites that are under consideration for nomination to the Register.

It was determined that four prehistoric sites are located within the proposed project areas (16TR2m 38, 63 and 79) and three are within the bounds of the unauthorized projects (16TR3 19 and 26). There are 31 historic buildings and structures located in or near the project areas.

Site significance, based on National Register criteria, was preliminarily evaluated for the seven prehistoric sites. Site significance criteria included: integrity of site, distinctive characteristics, and potential yield for contribution to the historic record. If the forced drainage levees are placed along the wetland/non-wetland boundary none of

the seven prehistoric and 31 historic sites appear to be in danger of destruction. However, they should be field checked during Phase II planning for individual projects.

Assessment of the location of 96 known prehistoric sites in the parish in respect to present habitat association showed that sites are located in all of the eight habitats. With respect to habitat association at the time of Indian occupancy, the present distribution is misleading. Subsidence and sedimentation have subsequently lowered and buried sites along with habitat environmental changes. In addition, Indian shell and earth middens and mounds result in elevated local topographic highs that support upland type vegetation in contrast to surrounding marshlands and swamplands. Past studies indicate that initial site occupations were on natural levees of both abandoned and active streams and bayous. Changes in the landscape subsequent to initial occupation explains their present habitat distribution. These are the reasons why there is a probability of finding sites in habitats that are presently not suitable for human occupation.

With the no action alternative there will be a probable continued deterioration of wetland types due to natural and man related processes associated with the deterioration phase of the Mississippi River deltaic cycles.

Saline, brackish, intermediate and fresh marshes will probably be gradually converted from a detrital base marsh system to an aquatic system. Also cypress-tupelo swamps and wet bottomland hardwoods will probably be gradually converted from organic based systems to aquatic systems.

There would be a probable increase in frequency and duration of flooding as related to net elevation decrease due to natural subsidence.

Probable residential, commercial and industrial property loss and damage will continue, resulting from periodic tidal and precipitation flooding. The probable change in habitats will result in a change of the types of species harvested. Also, there is a possible loss of real estate and associated revenues and taxes.

Construction of levees in the non-wetlands will prevent overland sheet flow from uplands to wetlands by concentrating flow to a point source discharge. This will result in a loss of freshwater flow to some areas and a major increase of freshwater flow to other areas. The source, velocity, renewal rate, and timing of water in a wetland ecosystem directly controls the spatial heterogeneity of wetlands and the nutrient, O_2 and toxin load of sediments. These secondary factors in turn control or modify such ecosystem characteristics as species composition and richness, primary productivity, organic deposition and flux and nutrient cycles.

Local uplands ecology within construction rights-of-way would probably be impacted by the alteration or loss of habitat and disruption of local communities and niches resulting from canal and levee construction.

Existing undeveloped non-wetlands which are in demand for residential, commercial, industrial and agricultural development may be utilized for canal and levee construction. This could result in a probable loss of revenues resulting from development of uplands for residential,

commercial and industrial complexes.

Project construction will provide additional drainage capacity and minor tidal flood protection to existing developments and provide probable incentives for development of marginal uplands within project boundaries once subject to periodic flooding.

Placement of the proposed collection canal and levee along the wetland/non-wetland interface will probably impact existing hydrology as described for the non-wetland alternative.

Construction activities in wetlands may adversely impact water quality by increasing turbidity, suspended solids, sedimentation and associated physical and chemical modifications. Toxic materials such as hydrogen sulfide, methane, and a variety of organic acids, ketones, aldehydes, etc. as well as heavy metals and pesticides which exhibit persistent toxic effects, may be released into the water column during dredge and fill activities.

Some terrestrial and aquatic species along the interface may be directly destroyed by construction activities. Construction of the proposed collection canal and levee and resulting probable short-term impacts within construction rights-of-way to local habitats and hydrology will disrupt food webs and microhabitat distribution.

As stated previously, existing residential, commercial and industrial developments within proposed project areas would be afforded improved drainage facilities and protection from minor tidal and back water flooding. Also marginal areas along the backslopes of the natural ridges will probably become more attractive to development once the area is under forced drainage. Property values for existing developments and proposed lands for development will probably increase under forced drainage.

Probable impacts to local hydrology resulting from the wetland alternative are similar to those previously described for the non-wetland and wetland/non-wetland interface alternatives. Additionally, impounded wetlands within project boundaries will no longer be subject to tidal flows. These impounded areas can also alter existing flow patterns of adjacent habitats.

Probable impacts to local water quality resulting from construction activities are similar to those described for the wetland/non-wetland interface alternative.

Probable impacts to local flora resulting from project construction are similar to those described previously for other levee alignments. Wetland vegetation encompassed within project boundaries will probably be gradually replaced by plant species indigenous to fresher habitats and/or drier soil conditions.

Probable impacts to local fauna resulting from proposed construction activities are similar to those previously described for the wetland/non-wetland interface levee alignment. Indigenous species inhabiting specific wetland types within proposed project boundaries may suffer a future loss of habitat resulting from a changing vegetation regime as described above. Levee construction will provide upland habitat within a wetland area, increasing habitat diversity. The proposed levees will act as

barriers and may impact aquatic organisms by reducing or eliminating export of detritus and associated nutrients to adjacent habitats. Terrestrial and aquatic species utilizing wetlands within proposed project boundaries for all or part of their life cycles will be adversely impacted by proposed project construction. Drier conditions resulting from the forced drainage of minor wetland areas may result in their being utilized for cattle grazing or other man-related uses. Because of the extensive salt water intrusion and subsequent erosion in areas adjacent to unauthorized projects, adverse impacts to project areas resulting from construction of the 5 unauthorized forced drainage projects is made to appear to be minimal.

Project construction, as discussed previously, would result in improved drainage facilities and protection from minor tidal and back water flooding. With project construction, it is most probable that property values will increase for existing and proposed residential, commercial, and industrial developments. Probable conversion of marginal wetlands to residential, commercial and industrial developments will result in a higher tax base but will also result in the economic loss of these wetlands' harvestable productivity.

Previously mentioned impacts resulting from project construction are those researched in the literature and probable to occur during dredge and fill activities. It is recognized that cumulative impacts could result from construction of the proposed 26 forced drainage projects.

Impacts to project areas resulting from construction of the 5 unauthorized forced drainage projects are evident. To what degree these impacts are beneficial, detrimental and/or irreversible has not been determined. It appears that these projects have maintained the integrity of enclosed wetlands by preventing saltwater intrusion and subsequent deterioration or conversion of these wetlands to open water areas as has occurred in adjacent unprotected habitats.

It should be emphasized that the 26 proposed projects have not been assigned in a priority sequence. Demographic needs, environmental alternations and economic considerations will determine the development of this forced drainage system. Each project proposed or unauthorized will include an Environmental Assessment detailing project specifics such as but not necessarily limited to levee alignments, mitigation based on Habitat Evaluation Procedures, endangered species and consistency with coastal management programs.

FINAL
ENVIRONMENTAL IMPACT STATEMENT

Terrebonne Parish-Wide Forced Drainage System
Terrebonne Parish, La.

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2.0 Introduction to the Project

2.1 Purpose and Need for the Project. The proposed parishwide forced drainage plan was created in 1971 in response to continued flooding in existing residential, commercial and industrial developed areas throughout Terrebonne Parish by (1) lack of capacity of existing drainage facilities to remove precipitation runoff; (2) moderate tidal flooding; and (3) backwater flooding resulting from high stages of the Atchafalaya River. Since that time to the present new residential and commercial developments have encroached into some of the low-lying areas and have experienced repeated flooding.

The existing deteriorated gravity drainage system is incapable of carrying the additional run-off from the continuing residential and commercial developments. Naturally occurring problems such as increased subsidence (Wicker, et al. 1980) and higher water levels also reduce the carrying capacity and discharge ability of natural drainage arteries.

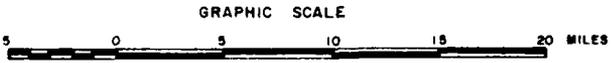
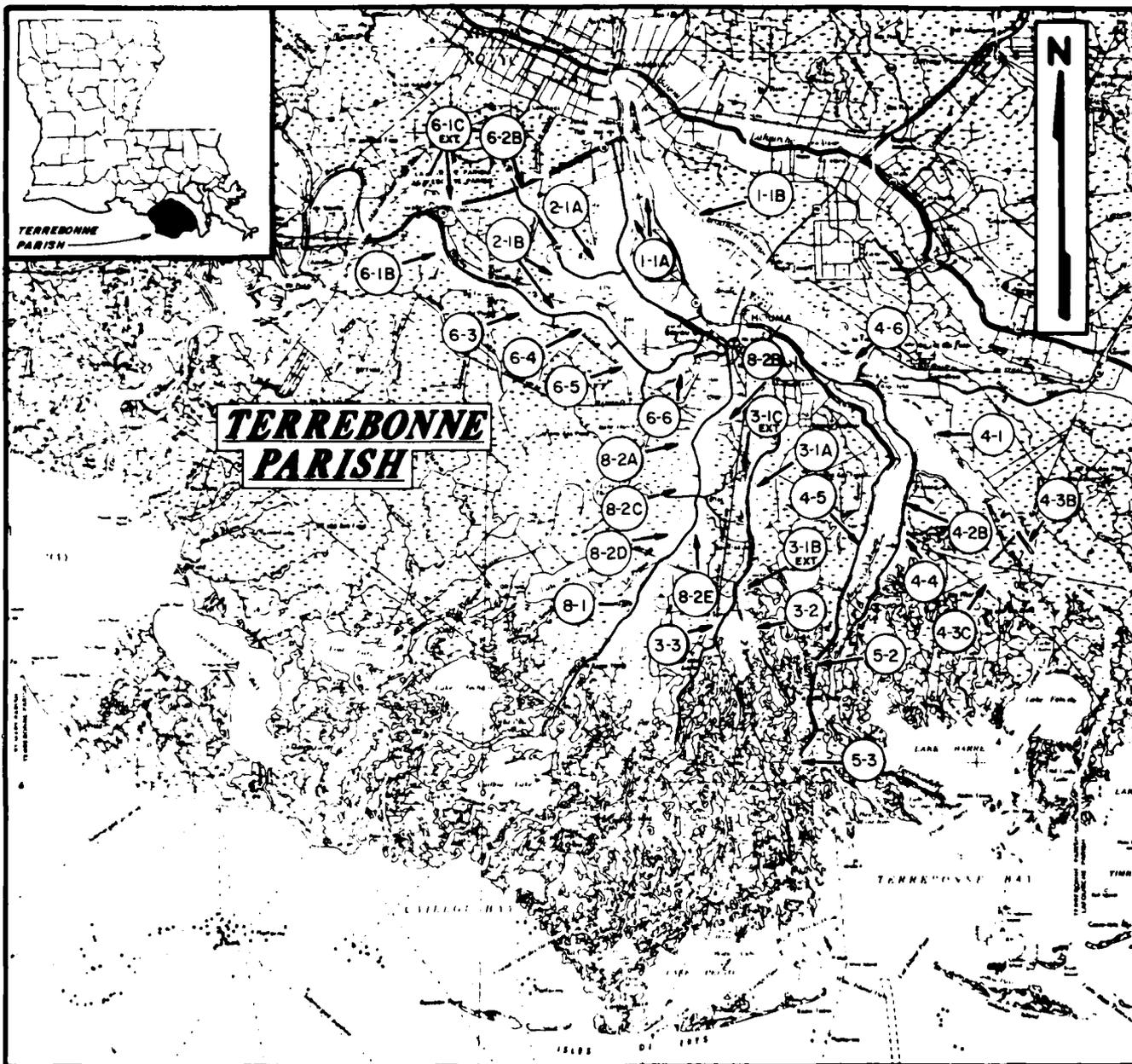
The 26 proposed forced drainage projects (Figure II-1) are designed (Figures II-2 and II-3) to be maintained by the local governing authority of the Parish and to provide controlled drainage to the existing and future residential, commercial, industrial and agricultural areas occurring on the natural ridges adjacent to the fingerlike network of bayous in Terrebonne Parish. In the southern portions of the parish the proposed project levees will provide protection against minor tidal flooding but are not designed as hurricane protection levees (Figure II-1). Likewise, in the northern part of the parish the proposed project levees will provide protection against minor backwater flooding resulting from high flood stages in the Atchafalaya River. These proposed levees will not provide protection against major flood conditions.

Also, there are five existing unauthorized forced drainage projects that were completed during the time the permit processes were being implemented.

2.2 Corps Authority. The Department of the Army acting through the Corps of Engineers is responsible for administering various Federal laws that regulate certain types of activities in specific waters in the United States and the oceans. The authorities for these regulatory programs are based primarily on various sections of the River and Harbor Act of 1899 (33 U.S.C. 401 et seq.) and Section 404 of the Clean Water Act (33 U.S.C. 1125 et seq.).

On 18 December 1968, the Department of the Army revised its policy with respect to the review of permit applications under Sections 9 and 10 of the 1899 Act. In addition to navigation other factors are addressed in the review of applications, such as fish and wildlife; conservation; pollution; aesthetics; ecology; and the general public interest (33 U.S.C. 209.120).

Section 404 of the Clean Water Act established a permit program to regulate the discharge, into the waters of the United States, of dredged material and of those pollutants that comprise fill material. Authority is given to the Chief of Engineers to grant permits within the Section 404 guidelines. Authority is further given to the Administrator, E.P.A., subject to certain procedures, to restrict or prohibit the discharge of any dredged or fill material that may cause an unacceptable adverse effect

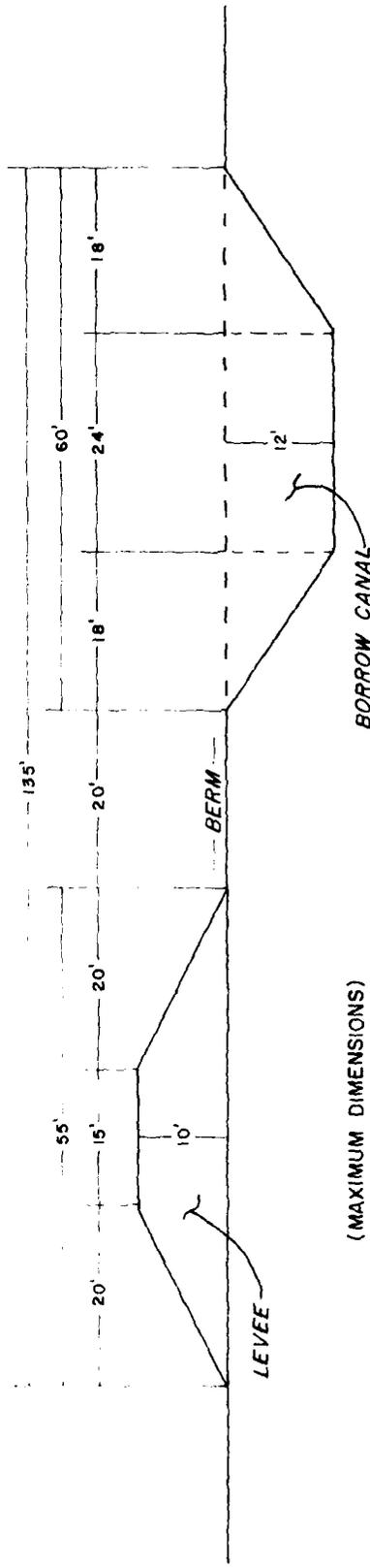


TERREBONNE PARISH-WIDE FORCED DRAINAGE ENVIRONMENTAL IMPACT STATEMENT

VICINITY MAP

T. BAKER SMITH & SON, INC. CIVIL & CONSULTING ENGINEERS, LAND SURVEYORS & ENVIRONMENTAL RESEARCH HOUMA, LOUISIANA	U.S. ARMY ENGINEER DISTRICT NEW ORLEANS CORPS OF ENGINEERS NEW ORLEANS, LOUISIANA
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FIGURE 11-1



(MAXIMUM DIMENSIONS)

NOTE DIMENSIONS OF LEVEES & BORROW CANALS WILL VARY
 DEPENDING ON EXISTING ELEVATIONS OF PROPOSED
 PROJECT AREAS

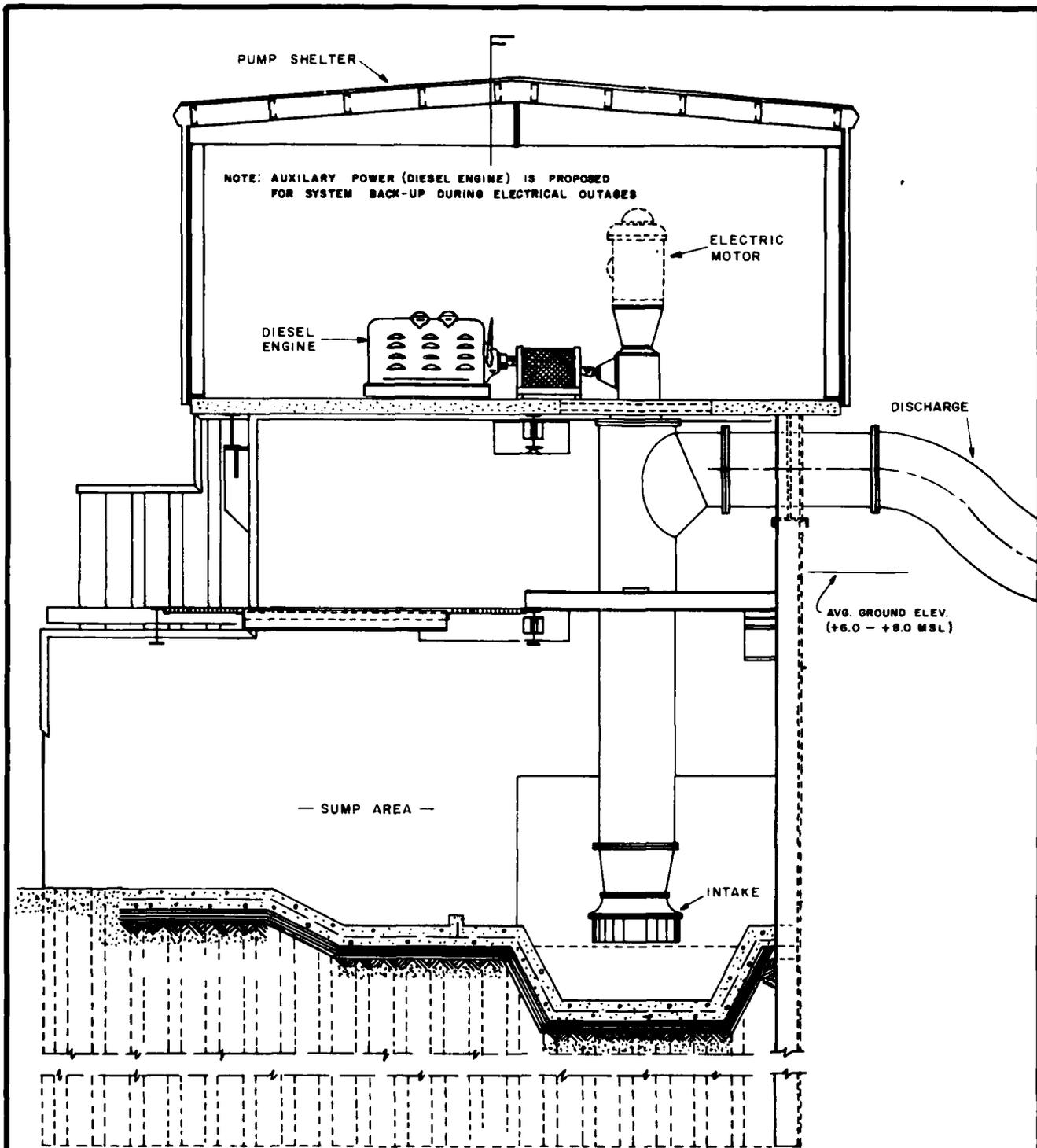


TERREBONNE PARISH-WIDE FORCED DRAINAGE
 ENVIRONMENTAL IMPACT STATEMENT

TYPICAL SECTION VIEW
 PROPOSED LEVEE & BORROW CANAL

T. BAKER SMITH & SON, INC. CIVIL & CONSULTING ENGINEERS, LAND SURVEYORS & ENVIRONMENTAL RESEARCH HOUMA, LOUISIANA	U.S. ARMY ENGINEER DISTRICT NEW ORLEANS CORPS OF ENGINEERS NEW ORLEANS, LOUISIANA
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FIGURE 11-2



NOTE: PUMP STATIONS WILL VARY ACCORDING TO NUMBER & SIZE OF PUMPS BASED ON DRAINAGE AREA

TERREBONNE PARISH-WIDE FORCED DRAINAGE ENVIRONMENTAL IMPACT STATEMENT

TYPICAL SECTION VIEW FORCED DRAINAGE PUMP STATION

T. BAKER SMITH & SON, INC.
 CIVIL & CONSULTING ENGINEERS,
 LAND SURVEYORS &
 ENVIRONMENTAL RESEARCH
 HOUMA, LOUISIANA

U.S. ARMY ENGINEER DISTRICT
 NEW ORLEANS
 CORPS OF ENGINEERS
 NEW ORLEANS, LOUISIANA

FIGURE II-3

on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas.

2.3 Public Concerns. Public concerns were submitted at a U.S. Army Corps of Engineers Scoping Meeting held on Thursday, 26 February, 1981 in Houma, Louisiana. Seventy-five individuals attended the meeting . representing various federal, state and local agencies, engineering/ environmental consulting firms, special interest organizations, newspapers and private interest including residents of the proposed project areas.

Issues raised at the scoping meeting were documented and categorized into groups consisting of costs, current flooding, effectiveness of projects, priorities among projects, and miscellaneous construction dates.

2.4 Project Objectives

2.4.1 Critical Objectives. These include providing forced drainage to those areas of the parish suffering high occurrences of repeated high water conditions resulting from altered natural drainage patterns, increased run-off from new development and minor tidal flooding. Project levees will act as a barrier to future encroachment and development of wetlands and protect nonwetlands from probable future tidal flooding, deterioration and erosion.

2.4.2 Desirable Objectives. The objective is to provide forced drainage parishwide to existing residential, commercial and industrial developments and all undeveloped agricultural and other nonwetlands that are probable for development in the future. Also significant wetlands unavoidably encompassed within forced drainage areas will be maintained as wetlands and protected from probable salt water intrusion and resulting alteration or destruction.

2.5 Decisions to be Made. This document is to provide the necessary information to the appropriate decision makers to select from among the proposed alternatives the one that meets all of the critical objectives and as many of the desirable objectives as possible, with the fewest environmentally damaging impacts.

2.6 Introduction to the EIS. The Terrebonne Parish-Wide Forced Drainage EIS is being prepared at the request of the U.S. Army Corps of Engineers, New Orleans District, to accompany a 404 permit application for 26 proposed projects and five existing unauthorized projects individually.

Information contained in the EIS is based on an outline prepared as a result of data obtained from workshop meetings with various federal, state and local agencies involved in environmental acceptance of the proposed program. Also considered in outline preparation was data obtained from a public scoping meeting held on February 26, 1981 in Houma, Louisiana.

This EIS should be considered a general statement for all 26 proposed and five unauthorized projects. Permit issuance cannot be realized until U.S. Army Corps of Engineers acceptance of the EIS and acceptance and approval of follow-up individual project environmental assessments. All normal procedures associated with public review relative to processing Section 10/404 Permit Applications will be in effect for each of the 31 forced drainage projects including possible mitigation measures and the right to elevation for review by higher authority.

3.0 Alternatives

3.1 Introduction to this Section. An infinite number of alternative levee alignments exist due to the enormous proportions of the proposed Terrebonne Parish-Wide Forced Drainage System. Alternatives were divided into three major groups encompassing levee alignments entirely on non-wetlands, levee alignments along the wetland/non-wetland interface and levee alignments encompassing large areas of wetlands. The "No Action" alternative will also be addressed as required by regulation.

3.2 Description of Alternatives

3.2.1 No Action. The Terrebonne Parish Police Jury's not implementing the proposed forced drainage program will result in areas already experiencing flood conditions to continue to do so with a probable increase in duration, extent and height of flood waters. The continued residential, commercial and industrial development resulting from the continued production of domestic and foreign energy exploration and production supplies and equipment will result in a probable increase of run-off, causing flood conditions. Without the proposed forced drainage program the continued development and intense competition for available high land will result in increased pressure to utilize marginal wetlands for further development opportunities. Minor tidal flooding will continue in the southern portions of the parish with continued subsidence and high tide stages. Many bottomland hardwoods, swamps and freshwater marsh associations within the proposed projects' levee confinements and proposed to be maintained as such will be subjected to saltwater intrusion resulting in habitat destruction or change. With this alternative the monies required to construct, operate and maintain an additional 26 forced drainage projects will not be required. Those adverse impacts on adjacent wetlands resulting from construction of the proposed forced drainage system will not occur.

3.2.2 Non-Wetland Alternative. This alternative consists of constructing the proposed project levees by depositing excavated or fill material only in non-wetland areas.

3.2.3 Wetland/Non-Wetland Interface Alternative. Construction of this alternative will consist of placing the proposed project levees along the demarcation line between non-wetlands and wetlands.

3.2.4 Wetland Alternative. The wetland alternative design has the proposed project levees placed out from the natural ridges within wetlands.

3.3 Evaluation and Comparison of Alternatives. The non-wetland alternative design results in no direct adverse impacts to wetlands resulting from spoil deposition in wetland areas. Adverse impacts to adjacent wetlands resulting from altered natural drainage patterns and flows from uplands to wetlands will occur. Upland vegetation occurring within the construction right-of-way will be removed and maintained in the future as a cleared right-of-way. Proposed collection, canal and levee construction in uplands will utilize highly demanded areas for residential, commercial, industrial and agricultural development.

The wetland/non-wetland interface alternative will consist of placing the proposed project levee alignments along the demarcation line between non-wetlands and wetlands. A minimal amount of wetlands are utilized with this design, resulting in fewer adverse impacts from dredging and spoil deposition activities. This alternative also impacts the natural drainage patterns and flows from the uplands to the wetlands. Those marsh, swamp and wet bottomland hardwoods occurring within the construction right-of-way will be destroyed. This alternative will allow for all or most of the non-wetland areas to be included within proposed project boundaries. Only minimal and unavoidable wetland areas included within project boundaries will be altered are adversely impacted.

A wetland design would consist of placing the proposed project levees at the rear of property lines of individual property owners along the natural ridges adjacent to the major waterways within the parish. This alternative would result in encompassing large areas of wetlands to be utilized as sump areas. All marsh, swamp and wet bottomland hardwoods within the construction right-of-way will be destroyed. All natural flow patterns and water levels within the wetland sump areas will be eliminated, resulting in adverse impacts to existing flora and fauna. This alternative would allow for drainage of all uplands and many wetlands.

Table III-1 summarizes probable acres of wetlands impacted by the previously described alternative levee alignments.

Table III-2 summarizes project acreage by habitat type for the preferred wetland/nonwetland interface alternative.

Table III-1. Wetlands Impacted by Alternate Project Designs

WETLANDS	LEVEE ALIGNMENTS		
	NON-WETLAND	WETLAND*	WETLAND/NON-WETLAND INTERFACE**
Acres	0	46,400	14,849

*based on previous rejected project design encompassing large areas of wetlands

**includes large areas of wetlands presently encompassed within unauthorized project areas

Table III-2. Project Acreage By Habitat Type

PROJECT	OPEN WATER	SALT MARSH	BRACKISH MARSH	INTERMEDIATE MARSH	FRESH MARSH	SHRUBNET	CYPRESS TUPELOGUM	BOTTOMLAND HARDWOODS	OTHER UPLANDS	TOTAL
1-1A	11				82		63	688	1,925	2,769
1-1B	11				13		547	1,651	8,159	10,381
2-1A							15	448	4,369	4,832
2-1B							53	610	4,722	5,385
3-1A	40				25			55	495	615
3-1B EXT								17	160	160
3-1C EXT								418	435	435
3-2	15		50	412	779		2	322	384	1,964
3-3				10					32	42
4-1			831		1,485	154	494		1,521	4,485
4-2B	174		41	136	520	137	326	181	1,500	3,015
4-3B									56	56
4-3C		3	23						58	84
4-4									142	142
4-5									132	132
4-6							83	44	996	1,123
5-3									16	16
5-4									10	10
6-1B							28	533	790	1,351
6-2B							2	29	177	208
6-1C EXT							3	16	34	53
6-3								27	647	674
6-4								49	988	1,037
6-5							42	4	685	731
6-6							31	65	682	778
8-1	54		760	185		342		226	278	1,845
8-2A	12					115	63	155	1,475	1,820
8-2B							58	68	1,422	1,548
8-2C					7		7	146	619	678
8-2D				484			136	372	294	1,286
8-2E				12	65		61	142	543	823
TOTAL	317	3	1,705	1,239	2,976	748	2,014	5,847	33,629	48,478

4.0 Affected Environment

4.1 Introduction to this Section. This section describes the major habitats and their associated physical, biological, social and economic components within the project areas and Terrebonne Parish proper. The distribution of habitats within the 26 proposed and five unauthorized project areas and locations and descriptions of proposed pump station discharges are included in Appendix A. Descriptions of eight major habitats are included at the beginning of each individual habitat discussion.

Habitats have traditionally been a focus of impact discussions. Habitats are characterized by accepted ranges on values of selected variables or components. These components, in turn, are affected by natural and man-induced processes and process changes. Therefore, the key to understanding habitat assemblages, changes and impacts is to understand the major driving mechanisms that induce change or maintain static conditions on the variables of concern. Changes in some variables may affect different habitats similarly (e.g. climatic change) while others may be discrete. In order to provide a framework for understanding this complexity, the detailed discussions are focused on the various physical, biological, social and economic variables. Subsequent habitat discussions include information on the variables of concern that are habitat specific and refer the reader back to the more inclusive discussions included below.

4.1.1 Physical

4.1.1.1 Meteorological and Climatological. The climate along the Louisiana coast is influenced greatly by its subtropical latitude and its proximity to the Gulf of Mexico. The climate of the Lower Mississippi Region is controlled to a large degree by the seasonal changes in the location and strength of the semipermanent high-pressure anticyclone of the southern North Atlantic Ocean and by connected variations in the patterns of development, movement and intensities of cyclonic storms in subtropical and middle latitudes (Lower Mississippi Region Comprehensive Study, 1974). Also, the marine tropical effect results from the fact that the average water temperature of the Gulf along the Louisiana shore ranges from 64°F in February to 84° in August (Sanders 1959).

Prevailing southerly winds in summer provide warm, moist, conditionally unstable maritime tropical air that moves in a convergent pattern over southern portions of the region throughout the summer season. The air is made increasingly unstable by its passage over the warmer land surface, and local showers and thunderstorms are a common afternoon occurrence. Whenever westerly or northerly winds interrupt the prevailing moist conditions during the summer, hotter and dryer weather results.

During the winter the project area is subjected to alternating cold continental air and warmer tropical air, causing drastic variations in climate conditions. Squall lines (instability lines) often develop 50 to 150 miles in advance of surface cold fronts moving across the coastal area. These extensive but narrow belts of heavy convection produce strong surface winds and heavy but usually brief rainfall. Unlike true fronts, they are transitory, ordinarily developing to maximum intensity in a few hours and then dissipating.

The mean monthly temperature is lowest in January and highest in August (Table IV-1). Mean temperatures vary only slightly in an east-west direction across the state. This pattern is basically latitudinal with some modification due to microclimatic effects and regional distributions of land and water.

Winters are usually relatively mild in the project area with an average January temperature of 55°F. Even in January the region is covered for considerable periods with warm, humid, maritime tropical air flowing northward from the Gulf of Mexico and the Tropical Atlantic. According to Kniffen (1968) the growing season along the Louisiana coast or the period between the last freeze in spring and the first freeze in the fall averages 317 days. During shorter periods the region is also dominated by very cold, dry continental arctic air. These sharp airmass contrasts make winter a season of strong temperature variability.

Summers in the project area are distinctly hot, with an average July temperature of 82°F. Absolute and relative humidity are also high. This combination of heat and humidity produces periods of oppressive sultry weather with little cooling power.

The Louisiana coast generally has an abundance of rainfall, with an annual average of 65.72 inches at Houma, Louisiana (Table IV-1). The rainfall is fairly well distributed throughout the year, with the maximum occurring in July and the minimum in October.

Hurricanes and tropical storms with strong cyclonic winds, high tides and torrential rain are occasional visitors, approximately 1 per 15 years, to the coastal region between June and November (Nichols 1959).

Snow is infrequent in the project area and when it does occur seldom remains on the ground for more than a day or two.

For more detailed information pertaining to the hydroclimate of the Terrebonne Parish vicinity, refer to Section 4.1.1.5.

TABLE IV-1. Mean Temperature

STATION	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
Donaldsonville	53.8	56.5	61.9	69.9	76.0	81.1	82.5	84.4	78.7	70.2	60.7	55.6	69.1
Franklire	53.7	56.3	61.1	69.0	75.2	80.2	81.7	81.7	78.3	69.9	60.8	55.6	68.6
Houma	55.2	57.7	62.3	69.8	75.4	80.3	81.6	81.6	78.3	70.3	61.6	57.0	69.3
Morgan City	54.3	56.8	61.8	69.9	75.9	81.1	82.4	82.4	79.1	70.9	61.4	56.1	69.3
N. O. Moisant	52.9	55.6	60.7	68.6	75.1	80.4	81.9	81.9	78.2	69.8	60.1	54.8	68.3
Schriever	54.3	56.7	61.4	69.0	74.8	80.1	81.7	81.7	78.1	69.7	60.8	56.0	68.7
PRECIPITATION NORMALS													
Franklin	4.10	4.84	4.35	3.82	5.40	6.01	8.48	7.32	6.28	3.24	3.93	5.04	62.81
Houma	4.69	4.61	5.24	4.35	4.79	6.72	8.13	7.20	7.66	3.32	3.89	5.12	65.72
Morgan City	4.46	4.92	4.51	4.43	4.81	5.66	8.36	7.10	7.03	3.67	4.14	5.24	64.33
N.O. Moisant	4.53	4.82	5.49	4.15	4.20	4.74	6.72	5.27	5.58	2.26	3.88	5.13	56.77
Paradis	4.90	5.27	6.26	4.28	4.89	5.32	7.50	6.33	6.81	2.85	3.94	5.13	63.48
Schriever	4.58	5.27	5.50	4.73	5.64	5.89	8.47	6.15	7.63	3.03	4.09	5.58	66.56
MONTHLY AND ANNUAL DIVISIONAL AVERAGES TEMPERATURE (°F)													
Division													
Southeast													
1941	55.8	53.3	57.5	70.2	75.0	80.3	82.5	84.1	81.1	77.9	60.0	58.9	69.7
1942	51.0	53.3	60.2	67.9	74.5	80.4	82.4	81.7	77.2	71.9	64.1	57.4	68.5
1943	54.9	57.6	60.8	69.3	77.8	82.0	82.8	83.3	76.9	67.8	58.5	55.1	68.9
1944	54.1	63.8	63.5	68.5	75.3	82.9	82.8	82.7	80.5	69.1	63.7	55.3	70.2
1945	54.5	61.3	68.8	71.1	73.6	81.7	81.2	82.6	80.3	70.0	64.9	52.4	70.2
1946	54.6	57.4	64.6	70.5	75.2	78.7	81.7	82.6	78.0	72.7	66.3	59.2	70.1
1947	56.8	50.4	57.2	70.5	75.7	81.8	80.9	82.4	80.3	75.5	61.2	55.9	69.1
1948	47.6	58.6	64.9	72.0	76.7	81.9	82.9	81.9	76.5	69.6	63.8	60.6	69.8
1949	60.2	62.1	62.3	67.4	76.5	81.3	81.9	81.9	78.6	74.8	60.3	59.9	70.6
1950	67.5	61.5	60.1	65.3	76.5	81.0	80.6	81.7	78.9	71.7	58.4	53.1	69.7
1951	55.9	56.7	63.1	66.0	74.6	81.1	82.8	85.2	80.2	73.1	57.3	00.0	69.7
1952	63.0	59.4	61.2	65.9	75.3	82.8	82.5	82.8	77.0	64.3	59.8	55.7	69.1
1953	57.3	57.3	66.8	68.8	77.5	82.8	81.9	81.8	78.7	71.5	61.1	54.4	70.0
1954	57.5	60.4	60.8	72.1	72.0	80.9	82.6	83.4	80.7	71.9	59.3	56.0	69.8
1955	54.5	58.7	65.5	71.0	77.6	78.5	81.4	82.2	80.6	70.5	61.4	56.8	69.9

TABLE IV-1 (continued)

Division	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1956	52.6	61.8	62.9	67.7	77.0	78.8	81.9	82.0	78.0	72.7	61.5	62.2	69.9
1957	61.2	64.1	61.6	69.8	77.0	81.1	84.0	82.1	77.7	67.4	62.7	56.0	70.4
1958	49.3	48.4	58.6	68.9	75.5	81.7	81.9	81.8	80.5	70.5	64.6	53.2	67.9
1959	51.1	58.2	59.8	67.2	76.6	80.5	81.5	82.5	79.9	73.4	59.6	55.7	68.8
1960	53.0	51.2	57.3	69.2	72.8	81.3	84.4	81.5	78.8	72.2	64.2	53.3	68.3
1961	48.8	59.4	65.7	65.5	73.6	78.6	81.1	80.4	79.1	69.9	62.6	58.0	68.6
1962	51.6	63.8	58.6	66.9	77.2	80.7	84.5	83.7	80.2	73.9	69.6	53.4	69.5
1963	49.6	50.7	65.1	72.4	76.8	80.6	82.3	82.8	79.2	72.8	62.3	47.7	68.5
1964	51.2	51.7	61.4	70.7	76.0	80.3	81.2	83.2	79.6	67.1	65.2	57.7	68.8
1965	56.6	55.2	59.5	72.3	75.8	80.1	81.9	80.6	78.5	68.7	66.4	56.7	69.4
1966	49.5	54.1	60.1	69.0	75.3	78.4	82.7	81.1	78.2	68.7	63.7	54.2	67.9
1967	53.6	54.4	64.3	73.2	74.2	80.5	80.5	79.9	75.8	67.6	61.4	59.3	68.7
1968	52.5	48.7	57.7	70.2	74.9	81.0	81.3	81.8	77.6	71.7	58.9	53.8	67.5
1969	54.8	55.4	55.1	69.0	74.3	81.4	83.1	81.2	77.4	71.0	59.5	55.2	68.1
1970	48.0	52.3	60.2	71.0	74.1	79.2	81.4	81.9	80.5	69.3	57.1	59.4	67.9
NORMAL	54.3	56.7	61.5	69.3	75.5	80.7	82.2	82.2	78.9	71.0	61.6	56.2	69.2

4.1.1.2 Topological. The highest natural land and drainage networks in Terrebonne Parish owe their origins to Mississippi River deltaic depositional processes and subsequent destructional forces. Typical of the Mississippi River deltaic formation, natural levees of active and former stream courses form the high ground for settlement in this near-sea-level setting. Between the trunk and distributary courses, inter-deltaic and inter-distributary basins have formed (Russell 1936; Morgan 1972). With connections to the Gulf of Mexico, these basins are filled with bays, lakes, marshlands and swamplands.

Near Thibodaux natural levees of former distributaries fan out in patterns similar to Head of Passes (Fig. IV-1) and flow generally south southeast toward Houma. Bayous Little Black, Terrebonne, Blue and Chacahoula comprise the major relict natural levees between Thibodaux and Houma. Near Houma, Little Bayou Black waters entered Bayou Black, a former Teche Mississippi River course and back-flowed toward Morgan City (Russell 1967).

At Houma a second branching system of stream courses occurred. Major courses include Bayou du Large, Grand Caillou, Petit Caillou, Terrebonne and Pointe-Aux-Chenes. Downstream along these courses other branching occurred as sediment laden waters flowed into shallow bays and the Gulf of Mexico. Examples of these include Bayou Mauvais Bois that flowed southwest off Bayou du Large, and Bayou St. Jean Charles branched off Bayou Terrebonne to the southeast into the Lake Felicity basin. About midway to the Gulf near Dulac, Bayou Grand Caillou branched into several distributaries that include Four Point, Grassy and Bluff bayous.

Through the banks of stream courses between Thibodaux and the Gulf of Mexico, crevasses and splays occurred. These processes constructed bulges and fingers of high ground into the inter-levee depressions as sediment laden waters breached or overflowed banks during periods of high river water.

The natural levees decrease in elevation from upstream to downstream. At Thibodaux the elevation ranges between 10-15 feet (300-480 cm) above National Vertical Geodetic Datum (NVGD) and decrease to about 10 feet (300 cm) at Houma sea level near their distal ends. Figure IV-1 indicates the general characteristics of natural levee configuration and displays the approximate position of the 5 foot (155 cm) contour line. Widths of the levees range from about 1.5 miles (2.4 km) for Little Bayou Black south of Thibodaux to a few tens of feet along smaller streams. Widths decrease downstream where they narrow to only a few feet gulfward. Levee crests attain levels established by overflow during high river water and their backslopes are ordinarily concave skyward. Backslopes vary in steepness from a decrease of 10 feet (300 cm) over a distance of a few hundred feet to less than 10 feet (300 cm) away from large channels. Radiating outward from Houma, the levees slope gently gulfward at about 0.7 ft. per mile and approach NVGD in the southern portion of the parish.

Elevation characteristics for natural levees along bayous in the project area are shown in Table IV-2 by project. The information was obtained from contours displayed on USGS Quadrangles and verified by survey records on file at T. Baker Smith & Son, Inc. The information in Table IV-2 is generalized and only reflects major trends along the segments of the bayous where the projects are located. The paucity of surveyed elevation control in the marshlands and swamplands prohibits refinement below the 5 foot (155 cm) contour line. Marshlands generally lie at about mean water level but this is complicated by storm tides and high gulf levels, high water in the Atchafalaya River and heavy rainfall within the Terrebonne Basin. Concurrently with the variable water regimes the area is subject to subsidence. It is likely that fresh water marsh surfaces lie slightly higher than saline marshes. Swamplands also vary; the lowest levels are present where pure stands of bald cypress occur. These are usually in areas flooded most of the time.

In most of the projects the wetland upland boundary extends along the natural levee backslopes near the 5 foot (155 cm) contour line or lower. Along most of the bayous in the downstream direction the elevation decreases to below the 5 feet (155 cm) above NVGD and are highly prone to floods.

Subsidence that occurs in the area lowers the land surface and affects both natural features and water control structures. It is an important consideration in planning for this project.

The term subsidence as used in this report refers to factors which are known to result in an apparent permanent lowering of the land with respect to water level datums. This normally includes only those factors that lower the elevation of the land, but some factors that raise the elevation of the water is included because (1) the net effect on the elevation displacement is the same; (2) it is frequently difficult to separate out the two components from available data sets and; (3) both the lowering of land elevations and the raising of water level elevations are active mechanisms in Terrebonne Parish.

Permanent change caused by subsidence is used in the context of the expected maximum lifespan of most construction projects (approximately 50 years). Related terms that are frequently used interchangeably with subsidence include "submergence" as in the rate of coastal submergence and "apparent sea level rise."

Except for the possible upward displacement of some sub-surface salt domes, all of Terrebonne Parish is undergoing subsidence. Subsidence can be perceived as a hazard as it increases the likelihood and magnitude of coastal flooding and is one of the processes responsible for wetland land loss in Terrebonne.

Subsidence is an effect and can result from a number of processes including several which are man-related. Subsidence related processes often interact, augment and probably have synergistic effects which vary spatially and temporally resulting in complex patterns. The major processes associated with the subsidence along the Louisiana coast have been compiled in a general manner by Adams *et al.* (1976) and provides a reference list of the more technical literature.

The Mississippi Deltaic Plain, in which Terrebonne Parish lies, is presently the most highly subsiding geological region along the United States Coast as evidenced by an analysis of sea level trends using tide gauges (Hicks 1968, 1972, 1978, 1981). During the past 40 years, submergence of the U.S. Coast (except Alaska and Hawaii) has averaged one-half inch per decade (Hicks 1981) but, as will be shown, Terrebonne Parish may be experiencing greater rates.

There is little data available to derive subsidence rates based upon stable reference datums. Despite numerous problems associated with survey bench marks (McEwen *et al.* 1976) they can provide useful datums provided their recorded elevations are not used as absolute elevations. Their use should be limited to showing only relative change in elevation through time. First order surveys are the most precise of bench mark elevation surveys. Several of these surveys were conducted along Highway 90 from 1919 through 1977 and provide a data base for the northern part of the parish.

Supplementing the elevation survey data are water level records obtained by various federal agencies including the Army Corps of Engineers, Geological Survey, and the Department of Commerce. Analysis of data from gauges in the vicinity of Highway 90 can be compared with elevation surveys of bench marks providing some degree of data reliability. Some differences in rates between the two data sets are to be expected, as the water level trends reflect all factors that contribute to net displacement of land and water, whereas bench mark surveys only reflect factors which contribute to land rising and sinking. Use of water level records also provides a data base for determining submergence in the southern part of the parish where first order surveys are not available.

In Watson's (1981) analysis of the re-leveling surveys of bench marks along Highway 90 from Baldwin to New Orleans, an average subsidence rate of 1.0 ft. (30 cm)/50 yr. was calculated. In reference to Terrebonne Parish only, 1.0 ft/50 yr. appears to be valid for Highway 90 west of Houma to the Assumption Parish line. Northeast of Houma along Highway 90 subsidence rates are approximately 50 percent greater; however, this may be an effect of differences in road construction. West of Houma, Highway 90 lies on top of levee deposits whereas northeast of Houma the road runs transverse to many of the levee deposits thereby crossing over less stable inter-levee basins. Thus the weight of the road and road surface may be locally accelerating the subsidence rate.

Long-term trends (several decades) in water level have been analyzed for the gauge at Amelia in St. Mary Parish (Baumann and Adams 1982) and for several gauges east of Bayou Lafourche (Baumann 1980). The tide gauge at Cocodrie was analyzed similarly to provide a better spatial resolution.

Water levels at Amelia after accounting for the year-to-year effects of Atchafalaya discharge have been significantly rising through time at a rate of 0.028 ft. (0.85 cm)/yr. since 1955 (Baumann and Adams 1982). Assuming this trend will continue into the future, mean water level at Amelia will appear to rise with respect to the present land surface by 1.4 ft. (42 cm) in 50 years. In addition to the effects of subsidence on the gauge at Amelia, the lengthening of the course of the Atchafalaya River through delta development is resulting in water level rise through time

given the same discharge. This rise is associated with decreased gradients and sediment deposition. It has been projected that given a once-in-a-hundred-years flood event, water levels in northwestern Terrebonne will be 4.0-5.0 (120-155 cm) feet higher in 50 years than they would be presently with the same flood event (USACOE 1981). The same effect but of lesser magnitude can also be expected for central and eastern portions of the parish.

The tide gauge at Bayou Rigaud behind Grand Isle has been reflecting an apparent sea level rise of nearly one-half inch (1.23 cm) per year for the past 25 years. If this rate continues for the next 50 years, sea level will apparently rise by approximately 2 feet (61.5 cm). The tide gauge at Cocodrie has been in operation since 1969 and has been recording an apparent rise in sea level of approximately 125 percent that of Bayou Rigaud. Extrapolating to the next 50 years results in a projected apparent sea level rise of 2.5 ft. (77 cm) at Cocodrie.

To the northeast of Terrebonne Parish, gauges at Des Allemands and on Bayou Chevreuil near Chackbay have been in operation since the mid-1960's and have been recording a submergence trend approximately 90 percent that of Bayou Rigaud or 1.18 ft. (51 cm) over the next 50 years assuming current trends will continue.

In summary, considering the limitations of data sets employed for analysis it is apparent that Terrebonne Parish is experiencing fairly rapid (from a geologic reference) submergence rates. The northern part of the parish where most of the forced drainage projects are located is presently subsiding at a range of approximately one foot (30 cm) per 50 years. In addition, factors such as possible eustatic sea level rise and the elongation of the Atchafalaya River system are contributing additional rises on the elevation of the water with respect to the land. Rises associated with the Atchafalaya River may be resolved by management practices (e.g. USACOE 1981), but there is little management can do to prevent or retard the other factors that result in coastal submergence.

The suggested management strategy proposed here is to recognize submergence as a long-term hazard to residents of Terrebonne Parish. The focus is to manage development and protect the existence of already developed areas.

Although precise subsidence rates cannot be determined on a project by project basis, it is suggested that an estimated subsidence rate be incorporated as a factor on the expected longevity of each of the projects. In order to obtain better spatial resolution of subsidence rates, an expanded data base should be sought. Incorporation of less than first-order surveys of bench marks into the data base is suggested despite some loss in precision. Bench marks are contained within most, if not all, project areas. It is further suggested that efforts be made to obtain the releases of proprietary first-order survey data.

In addition to the rates and effects of subsidence through land lowering and rising water levels, the projects can affect local subsidence rates through weight of material loaded on the surface. It is unlikely that the projects which are confined to the natural levees will affect subsidence rates to any appreciable extent beyond that which has already occurred or is occurring from the weight of existing roads, buildings, etc. Projects that span and impound inter-levee wetland basins possess the potential to accelerate subsidence. It can be expected that these areas will sink if enclosed small basins are pumped dry. The degree to which the local water table is lowered and the relative amount of organic material present in the substrate are major controlling factors. The numerous failures of marsh reclamation projects that dot the deltaic plain landscape provide visible evidence of surface subsidence due to oxidation and compaction of organics resulting from lowered water tables. This type of subsidence problem occurs during a relatively short time period and is irreversible once it occurs. It is recommended that in the project areas that extend across levee systems, an analysis of the subsidence potential caused by pumping be performed for each location. It is suggested that should the above problem potentially exist for any project area, the feasibility of maintaining the natural water table be considered. This would limit pumping to drain off surplus waters only and would help to prevent oxidation and shrinkage from occurring. It should also be noted that impounding prevents the external introduction of sediment to the area. The input of sediments as well as the formation of peats are important processes in maintaining the elevation of the marshes with respect to subsidence. If water levels are not favorably maintained for peat development, it can be expected that the marsh will be lost to more aquatic habitats due to long-term subsidence related processes.

4.1.1.3 Geological. The geology of Terrebonne Parish is intricately interrelated with delta development in coastal Louisiana. The parish lies astride several overlapping deltaic sequences of sedimentation that are complexly intercalated in time and space. During periods of deltaic construction, depositional processes dominated and Mississippi River distributaries were extended gulfward building new land. Shifts in the river to other localities decreased sedimentation and allowed the onset of destructional forces and gulf processes became dominant (Coleman and Gagliano 1964; Morgan 1974). Contemporaneously with depositional and erosional sequences, sea level changes, mainly rising, and land subsidence was occurring.

In planning for maintenance and multiple use of the physical and biological resources of the area, both short and long term geological processes need to be brought into focus. Louisiana's continental shelf beaches, barrier islands, bays, lakes, marshlands and swamplands constitute major environments that provide richly endowed habitats for wildlife and fisheries production. Terrebonne Parish is well endowed with all of these habitats. The relatively narrow fingers of natural levees extending through and in close proximity to these environments provide the high ground for settlement.

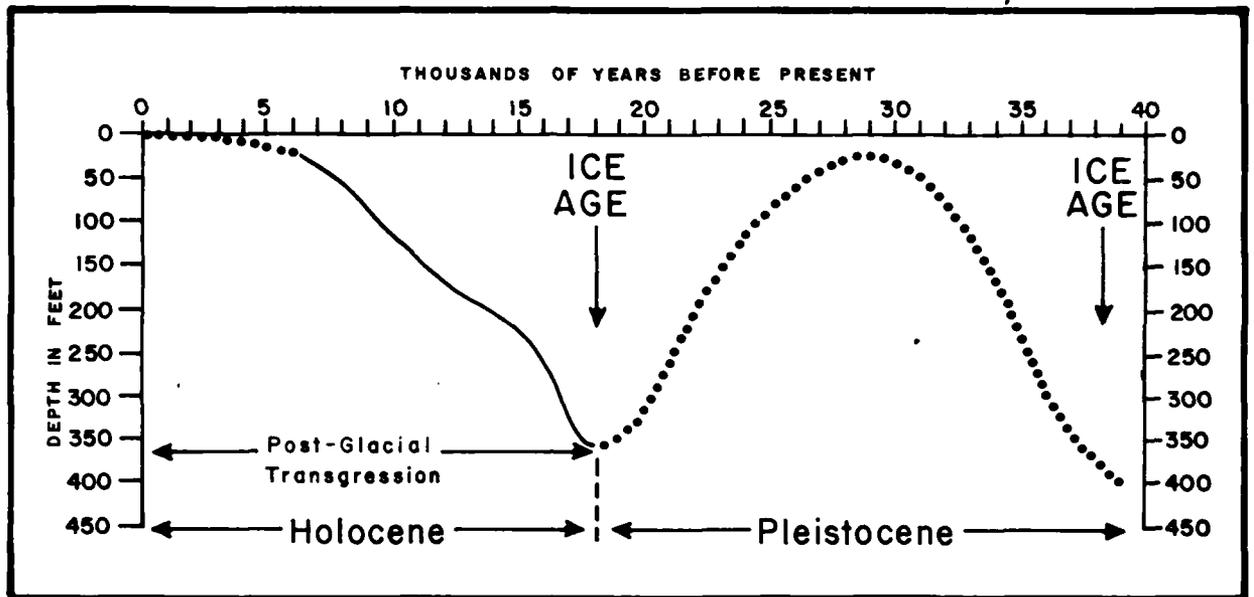
The geological episode referred to as the Holocene or Recent spans about the past 17,000 years (Morgan 1970). Holocene time is characterized by ameliorating climates and sea level rise. There are four significant geological processes operating contemporaneously that have contributed to the present deltaic landscape in Louisiana. These include: sea level rise; deltaic formation by the Mississippi River; land subsidence; and destructional processes.

4.1.1.3.1 Sea level changes. At the culmination of the last glacial period, ice covered large areas of the polar and mid-latitude continental land areas. During Holocene times almost two-thirds of this ice melted and water returned to the seas. Melt waters resulted in sea level rise from a position about 400 feet (120 m) below present level (Figure IV-2) (Fisk 1954; Russell 1936; Saucier 1974; Adams *et al.* 1978; Kolb and Van Lopik 1958). Rates of rise are thought to have been more rapid at first but diminished during the past 7,000 years (Morgan 1970). There is disagreement by students working on the problem on details of sea level changes, and definitive work remains to be done. However, in coastal Louisiana available evidence indicates that sea level rise continued at a decelerating rate and reached its present level about 3,000-3,500 years ago (Coleman and Smith 1964; Coleman 1966).

During this major marine transgression, shorelines have receded from approximately the edge of the continental shelf to its present position. Shoreline features such as beaches and barriers were left inundated on the shelf. Sandy deposits, such as Ship Shoal that lies about 15 miles seaward of Isles Dernieres, is likely a beach or barrier island feature, but more study is needed (Morgan 1970). Since that time there have been only minor changes, measurable in terms of a few feet.

More precise data on sea level changes are available from continuously recording tide gauges that are maintained near sea ports. These gauges have been in operation for only a short period of time. The first tide gauge established in the Gulf of Mexico at Galveston was in 1909. Over this relatively short period of time the recordings show a rise of over one foot (32 cm) (Marmer 1952). Since the gauge was mounted on pilings, records show both sea level rise and subsidence of the land. It is difficult to separate the two processes with this kind of record. However, general trends can be shown by comparing gauge readings at Pensacola, Florida that is considered stable with the Galveston gauge and other gauge readings in Louisiana (Swanson and Thurlow 1973).

The general trend, despite the lack of precise data, shows that there has been a resulting inundation or marine transgression. Although a one foot (32 cm) relative rise in sea level as shown by the Galveston gauge appears to be an insignificant amount, in the low marshlands and swamplands of coastal Louisiana many hundreds of square miles are inundated. Such transgressions result in environmental changes affecting animal and plant habitats. In recent years the natural changes have continued concurrently with increased human use for recreational, commercial, and mineral exploitation. It is difficult to separate the amount of impacts caused by man's activities from those occurring naturally.



MODIFIED FROM CURRY, 1965.

TERREBONNE PARISH-WIDE FORCED DRAINAGE
ENVIRONMENTAL IMPACT STATEMENT

GENERALIZED CURVE OF LATE QUATERNARY
SEA LEVEL FLUCTUATIONS

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FIGURE IV-2

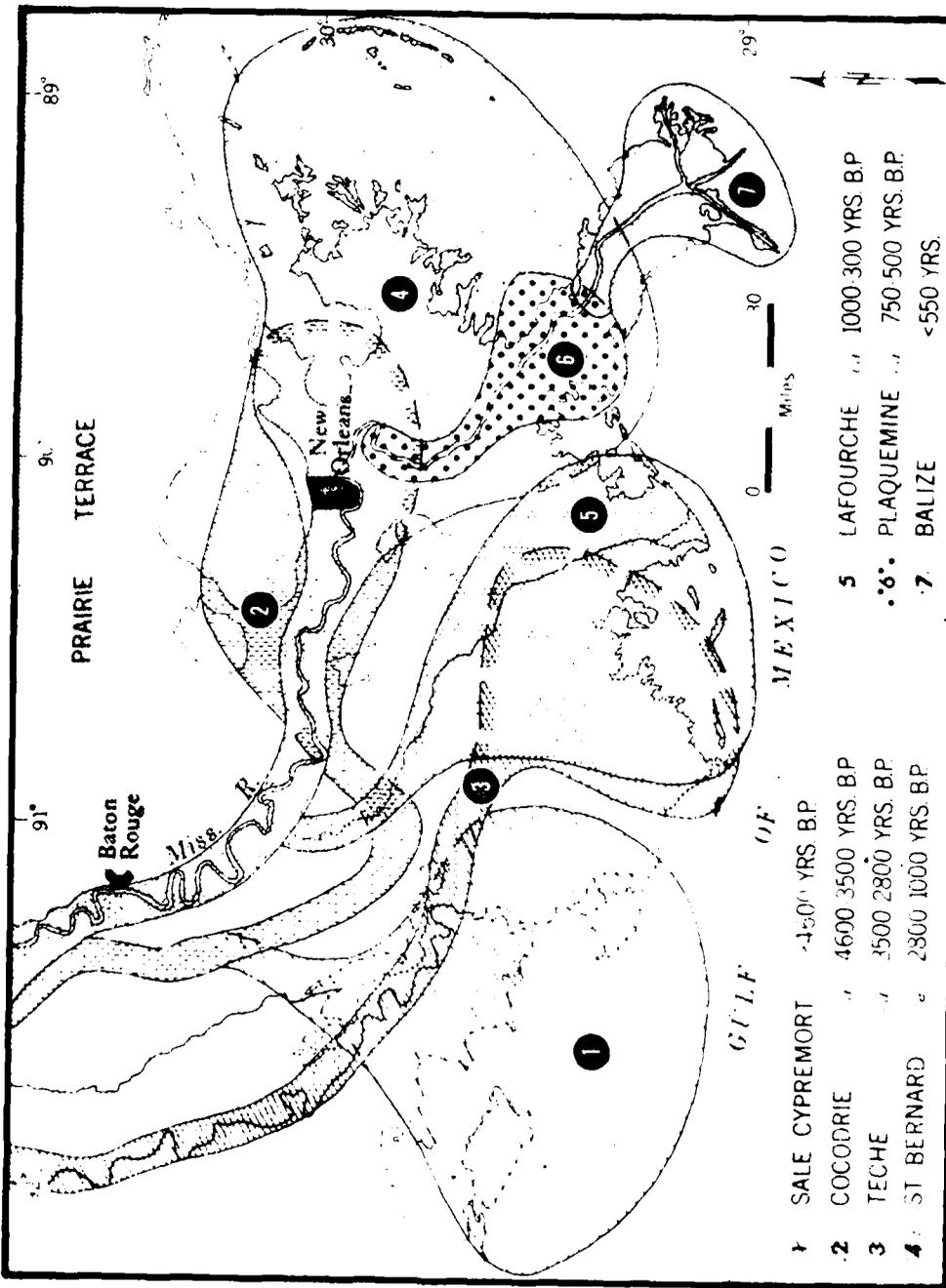
Lunar and wind tides cause short-term changes in water levels that are important dynamic processes to consider. Gulf coast lunar tides average about 1.5 feet (46 cm) and are mainly daily rather than twice daily as is the case in most parts of the world. When combined with wind tides their effect can be dramatic. Wind tides can occur throughout the year and often exceed the elevation of lunar tides. South winds raise water levels by transporting marine waters into the coastal lowlands. North winds reverse the process and force water gulfward, resulting in depressed levels in the marshlands and bays. These forces result in a continuum process for nutrient and water exchange between the gulf and coastal waters. Storms accentuate the processes and result in erosion of shores and coasts.

In addition to lunar and wind tides affecting water levels along the Terrebonne Parish coast, variations in gulf levels and fresh water runoff occur seasonally. Raised gulf water levels occur during the months of September and October (Byrne et al. 1976). The causes are not fully understood and need investigation (Baumann 1982). Additional problems relevant to fresh water discharge was discussed in the topological section.

4.1.1.3.2 Deltaic Formation. Deltaic formation that contributed to the present complex land area began about 7,000 years ago when sea level was a few feet lower than present (Morgan 1970). At about this time the marine transgressive began to slow and deltaic sedimentation, previously overwhelmed, became more pronounced. About 5,000 years ago the focus of deposition was in central coastal Louisiana, the location of the Sale-Cypremort delta (Fig. IV-3).

Gulf level at that time was approximately 10-15 feet (3-5 m) below present level. The Mississippi River favored a more eastern course and abandoned the Sale-Cypremort (Kolb and Van Lopik 1958) and subsequent sea level rise and wave attack reworked the deltaic mass. Trinity and Tiger shoals, seaward of the Atchafalaya Bay, remain as submerged bars (Morgan 1973).

Cyclical deltaic sedimentation by the Mississippi River has been rather thoroughly described (Kolb and Van Lopik 1958; Scruton 1960; Coleman and Gagliano 1964; Morgan 1970; Gould 1970) and can be briefly summarized as follows: On reaching the Gulf (base level), an alluviating river such as the Mississippi is forced to deposit its entrained sedimentary load because its flow-velocity diminishes. Resulting sedimentary deposits accumulate, forming a delta and gradually building seaward (prograding). The river branches time and again to form an anastomosing, radiating pattern typical of deltaic distributaries. As each distributary lengthens, its gradient diminishes, and the channel becomes increasingly inefficient. The deltaic distributaries ultimately cannot handle their water and sediment loads, and the river is forced to divert through some distributary that has a shorter route (and steeper gradient) to base level. During the past several thousand years, this sequence has reoccurred several times, with the result that the river has fashioned its deltaic plain from a number of overlapping deltaic lobes (Figure IV-3). Subsidence, mainly compaction of soft, newly deposited sediments, has allowed later delta lobes to prograde across and over older sequences. Erosion, sea level rise and subsidence have nearly obliterated the surface expression of this early delta.



MODIFIED FROM KOLB AND VAN LOPIK, 1958.

TERREBONNE PARISH-WIDE FORCED DRAINAGE ENVIRONMENTAL IMPACT STATEMENT

CHRONOLOGY OF DELTAS THAT COMPOSE THE HOLOCENE MISSISSIPPI RIVER DELTAIC PLAIN

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FIGURE IV-3

About 3,500 years ago sea level reached a near standstill with only minor fluctuations since then (McIntire 1969). During this period deltaic deposition became the dominant process leading to the development of the broad deltaic plain (Figure IV-3) in southeastern Louisiana (Kolb and Van Lopik 1958; Frazier 1967; Gould 1970).

As shown on Figure IV-3, the several sites or "lobes" of deltaic sedimentation have alternately shifted from east to west and gradually prograded or built seaward across the continental shelf. The present (Balize) delta has now prograded to within a few miles of the shelf edge. Because this delta is prograding into relatively deep water it is building seaward very slowly and has fashioned a relatively small, but thick, sedimentary deposit. More significantly, most of its sediment load is being deposited in deep water and thus lost to the system.

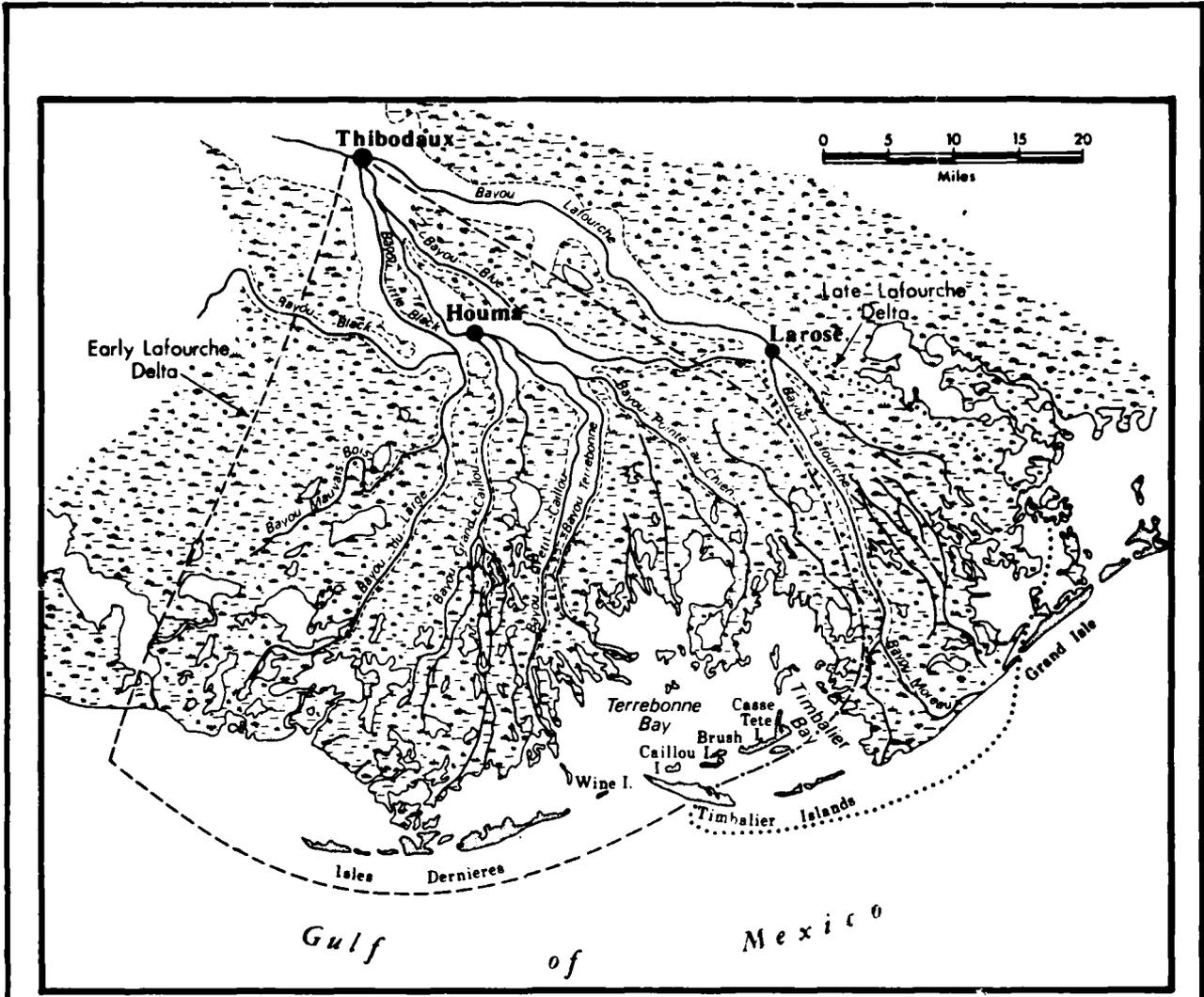
Early in the twentieth century the Mississippi River began discharging some of its flood waters into the basin drained by the Atchafalaya River. For about a half century the sedimentary load of the Atchafalaya gradually and progressively filled the numerous lakes, ponds and depressions within the basin. During the past decade or so, however, the sedimentary load has been finding its way into Atchafalaya Bay and a new delta, another diversion of the Mississippi River, is effectively initiated.

Terrebonne Parish lies within the region constructed by the Teche Mississippi and Lafourche Mississippi delta complexes. Frazier (1967) refined the delta sequences reported in 1958 (Kolb and Van Lopik) through analysis of peats associated with sedimentary sequences. He also showed that Mississippi River distributaries flowed contemporaneously in several parts of the deltaic plain and consequently river diversion is a complex process occurring over long periods of time. His study delineates the early Teche Mississippi and indicates it was formed about 5,500 years ago and the lobe extended eastward to approximately Houma. Bayou Black (Fig. IV-4) is considered to be located in a former Teche Mississippi channel.

Frazier's (1967) study delineated five sequences of sedimentation associated with the Lafourche Mississippi delta complex. Sedimentation sequences were also found to be older than previously reported by Kolb and Van Lopik (1958). The Lafourche Mississippi sequences in Terrebonne Parish include:

Bayou Terrebonne	3500 - 2100 years ago
Bayou Blue	1900 - 1800 years ago
Bayou Black	1700 - 1100 years ago
Bayou Lafourche and Terrebonne	800 - 80* years ago
Bayou Lafourche	300 - 80* years ago

*Bayou Lafourche was artificially closed in 1903-04.



The dashed lines encompass the general area of sedimentation for the early phases of the Lafourche Mississippi delta. Dotted lines outline the general area of the late phases. Bayou Lafourche was artificially closed in 1903-04 (Elliott 1932).

TERREBONNE PARISH-WIDE FORCED DRAINAGE ENVIRONMENTAL IMPACT STATEMENT	
EARLY PHASE OF LAFOURCHE MISSISSIPPI DELTA	
T BAKER SMITH & SON, INC. CIVIL & CONSULTING ENGINEERS, LAND SURVEYORS & ENVIRONMENTAL RESEARCH HOUMA, LOUISIANA	U.S. ARMY ENGINEER DISTRICT NEW ORLEANS CORPS OF ENGINEERS NEW ORLEANS, LOUISIANA
FIGURE IV-4	

The understanding of how the Mississippi River has constructed the deltaic plain provides insights into the complex geologic history of Terrebonne Parish. River diversion is a slow and continuing process. Old trunk and distributary channels can be reoccupied by later flow, and the river can be discharging in a number of localities at the same time. This was the situation in Terrebonne Parish.

The general focus of the early and late phases of the Lafourche Mississippi delta complex is shown in Figure IV-4. Sea level rise, land subsidence and sedimentation has resulted in burial of some of the older distributary systems. Artificial closure of Bayou Lafourche at Donaldsonville in 1903-04 severed Mississippi River water and sediments from the area. At the time of closure, it is thought that the bayou was discharging about 32,000 cfs (Elliott 1932).

Bayou Black is complexly related to three distinct river systems occupying the same general channel. The Teche Mississippi River formed the original channel before diverting to the eastern side of the alluvial valley. Following the diversion of the Mississippi River from the Teche channel, the Red River continued to flow within the levees of the master stream for a relatively long period of time before diverting elsewhere (Russell 1938). Red River deposits of characteristically reddish-orange colored sediments formed natural levees within the former Mississippi River channel. The reddish-orange color is in contrast to the gray-brown sediments transported by the Mississippi River. These deposits can be traced to west of Houma in the substrate. Later Mississippi River changes resulted in forming the Head-of-Passes for the Lafourche channel of the river near Thibodaux. Bayou Black, a distributary off the Lafourche Mississippi system, entered the former Teche-Red River channel near Houma and back-flowed up the former course to near Morgan City where it flowed southward into the Gulf of Mexico. Bayou Black sediments buried both the former Teche Mississippi and Red River deposits. These river changes spanned a sufficient length of time for land subsidence to lower the Teche Mississippi and Red River levees to near or below present sea level.

4.1.1.3.3 Land Subsidence. Since the subsidence problem affecting Terrebonne Parish was covered in the topological section, this discussion will be confined to processes that are relevant to the regional geology of deltaic construction and deterioration. The east-west-trending Louisiana coastline generally follows the axis of a downwarped section of the continental margin known as the Gulf Coast Geocyncline. Tens of thousands of feet of deltaic and shallow-marine sediments have accumulated in this subsiding trough during the past few tens of millions of years. These Cenozoic-age sediments are the source beds for south Louisiana's rich petroleum and natural gas accumulations. The geosynclinal sediments reveal a nearly continuous record of basin subsidence contemporaneous with sediment deposition. Such subsidence continues to affect coastal Louisiana, but at rates that become significant only when considered in spans of many thousands of years.

A more significant, short-term factor is the localized subsidence that accompanies compaction and water expulsion from newly-deposited sediments. Vast quantities of river-borne sediment are dumped rapidly as the Mississippi River builds its delta seaward at the continental margin. Initially, this sediment contains a large proportion of water trapped in the voids among the sediment particles. As sedimentary

deposits accumulate, loading causes much of the interstitial water to be driven out with a resulting compaction and subsidence of the surface. Deltaic deposits are composed dominantly of clay and silt-sized particles with a smaller percentage of fine-to-very-fine sand. In addition, there is a highly variable but significant quantity of deteriorating and decomposing organic material--products of the marsh and swamp flora that grow so profusely in Louisiana's deltaic environments.

In general, the amount of subsidence resulting from compaction is proportional to the thickness of sediment being compacted. Sediments deposited during the Holocene (Recent) geological episode are those which contain high fluid contents and are thus subject to compaction. Geologically older materials (Pleistocene or Tertiary) have lost most of their original interstitial fluids and are thus not as subject to compaction. Hence, subsidence rates in Louisiana are proportional to thickness of Recent sediments. Details of Recent sediment thickness of the deltaic plan are not well-known except that they delineate a wedge of sediment thicker toward the Gulf and thinning to the north, east, and west. Maximum Recent sediment thickness occurs in the delta plain south of New Orleans and at the mouth of the active delta. It is within these areas that subsidence rates through compaction should be at a maximum.

4.1.1.3.4 Destructional Processes. Delta construction and destruction are continuous processes vying for dominance with sedimentation decrease in one area and increase in another as the river shifts its course. During the process of diversion, one site of deltaic sedimentation is progressively receiving less sediment while another is receiving more (Fisk 1952). The processes of sediment compaction continue unchanged, however, with the result that abandoned deltaic areas gradually subside, allowing Gulf waters to invade interior lowlands. The seaward edges of these deltas, being deprived of new sediment, are exposed to the full erosional forces of Gulf waves and currents. Fine-grained deltaic materials such as silts, clay and organics are removed by wave erosion leaving as a residual deposit the coarser sands and shell materials. These fragmental materials are fashioned by wave action into narrow beach deposits fringing the periphery of the subsiding abandoned delta marshlands.

As subsidence continues, waves progressively rework the fringing beaches and underlying deltaic deposits, adding the coarser particles to the beach deposit including shells of organisms, while winnowing and removing the fines. Where sand is abundant, broad, thick beaches develop; where sand is deficient, beaches are narrow, thin and composed dominantly of shell fragments. By this process of accumulation the marshland beach gradually grows in size as it retreats across the deltaic marshlands toward the interior.

In a recently abandoned delta the beach deposit is small, subsidence rates are high, and coastal retreat is rapid. In older deltas the beach deposit increases in size and it cannot be reworked landward as rapidly as subsidence and salt water intrusion destroy the interior marshlands. Gradually the beach deposit is left behind, still migrating landward, but separated from the marshland by a bay or open body of water. The marshland beach thus gradually becomes a deltaic barrier island.

Once the deltaic barrier islands are formed, they receive their nourishment primarily from erosion attacking the marshland sea edge. The sediments are winnowed by wave action and littoral currents. The coarse sediments are transported downcurrent where they accumulate on the barrier island (Kwon 1969). Depletion of delta front material results in deficient material to maintain them. Barrier island erosion becomes dominant.

Beaches in Terrebonne Parish are all related to marine destruction and reworking of Mississippi River deltaic deposits. No sediments are derived from older than Holocene deposits nor from nondeltaic continental shelf material. Therefore a classification of the beaches and barrier islands must be related to delta development and destruction. Marshland beaches and deltaic barrier islands characterize the coast landforms.

Marshland beaches extend along the Terrebonne coast from Point au Fer to Caillou Bay, a distance of about 25 miles (40 km). This stretch of the coast extends across the eastern lobe of the Sale-Cypremort, the Teche and Early Lafourche Mississippi deltas. Through subsidence, sea level rise and wave attack, the Sale-Cypremort and Teche deltaic remnants lie well below present sea level. Marine processes have dominated this area for a relatively long period of time and coastal erosion has been severe. Typical of marshland beaches, a narrow, relatively thin layer of shelly sand caps the marshland sea edge. Marsh remnants in various stages of decay are frequently exposed along the strandline.

Morgan (personal communication) updated his 1974 and 1977 studies to include the EPA Infra-red photo coverage of 1978. He concluded that shoreline erosion was accelerating. His calculations show that measurements taken from air photo coverage between 1954 and 1969 showed a loss of 535 acres over the 15 year period for this marshland beach section. Between 1969 and 1978 the amount increased for the 10 year period to 884 acres. The acreage computed for the 46 year period 1932-1978 showed a loss of 2,589 acres. The rate of retreat between 1969 and 1978 amounts to about 24 feet (8 m) per year.

It should be emphasized that the deltaic barrier islands differ significantly from non-deltaic barrier islands of the Gulf and Atlantic coasts. Non-deltaic barriers were formed mainly against older than Holocene age deposits during the marine transgression. As a group they should be older in age and the sand that comprise them is usually coarser than the deltaic barriers. Since the coarse materials that the Mississippi River transports to the Gulf are fine to very fine sands, those are the sediments that form the barrier islands.

The barrier islands fronting Terrebonne Parish were formed from deteriorating Lafourche Mississippi delta complexes (Figure IV-3). The Early Lafourche was abandoned in favor of the Late Lafourche delta and the beginning phases of the Balize or modern delta some time before Europeans moved into the Gulf Coast. For the past few hundred years the numerous radiating deltaic distributaries of the Early Lafourche complex have continued to subside, lakes and bays have enlarged in the lowlands between distributary ridges, and a series of deltaic barrier islands (Isles Dernieres, Wine I., Caillou I., and Brush I.) have formed and migrated landward under the influence of wave action and coastal currents.

River diversion from the Early to the Late Lafourche system probably was not a sudden event but one that required several centuries or so. As Bayou Lafourche received an increasing volume of water and sediment, it prograded rapidly and built at least one major subdelta to the southeast of the present town of Larose (Figure IV-4). In its final phase of progradation, Late Lafourche distributaries extended seaward, well beyond the destructional barrier island shoreline of the Early Lafourche system.

Diversion of the Mississippi from the Late Lafourche subdelta to its modern site took place several hundred years ago, and by the time of earliest historical records and maps, the Late Lafourche system was well into its destructional phase. Wave attack on the distributaries and marshes caused rapid shoreline retreat, and the coarser fractions (fine and very fine sands) were concentrated to form the forerunners of Timbalier Island. With continued deltaic deterioration the Timbalier Island barrier island complex formed.

Map comparison by Morgan and Larimore (1957) and later updated by Morgan (1977), and personal communication, 1980 studies by Wicker and Adams et al. (1978) show accelerated area loss and coastline retreat in the barrier island systems. While Timbalier Island has retreated landward under wave attack, it has also migrated westward under the influence of the prevailing coastal currents. During a period of 116 years, the west end of Timbalier Island has moved northwestward about 4.25 miles (6.8 km), establishing a new shoreline trend seaward of the Caillou-Brush island remnants of the early Lafourche delta.

Morgan (personal communication 1980) said that shoreline loss for Isles Dernieres between 1932 and 1978 averaged 27 feet (8.2 m) per year. Between 1969 and 1978 the rate of shoreline loss accelerated to 63 feet (19 m) per year. Wicker (1980) shows a retreat rate for Timbalier Island to average 41 feet (12.7 m) between 1955 and 1978.

Area land loss for the deltaic barriers is also dramatic. Morgan indicates that between 1969 and 1978 Isles Dernieres lost over 900 acres. Timbalier Island experienced a loss of about 530 acres during the 10 year period (1969-1978).

Diminished sizes of the barriers also indicate that inlets between islands have widened. Inlets through the Isles Dernieres have opened up about one mile (1.6 m) over the ten year period between 1969 and 1978. Inlet widening increases exposure of inland bays and marshlands to marine waters. There are no time-depth studies on the measurement of inlet profiles, consequently computing water volume increase between the bays and the Gulf attributable to inlet widening is not possible.

The trend of land loss through the destructive processes of sea level rise, subsidence, sediment deficiency, and waves and currents extends inland affecting water and land habitats. The processes are enhanced by accompanying salt water intrusion.

Habitat alteration and land loss studies have been made by Gagliano, et al. (1970), Chabreck (1978), Adams et al. (1978), Craig et al. (1979) Wicker et al. (1980), and Gagliano et al. (1981) that show dramatic changes in the coastal environments. For a more comprehensive treatment, reference should be made to the above cited publications. The messages of each study are the critical changes that are occurring and the need for in-depth multiple use planning, maintenance and management.

Chabreck resurveyed his 1968 profiles in 1978 and by comparing the changes in marshland habitats over the 10-year period showed the results listed below for Terrebonne Parish.

Fresh marsh altered to intermediate	101 sq. mi.
Fresh marsh altered to brackish	22 sq. mi.
Intermediate marsh altered to brackish	30 sq. mi.
Brackish altered to saline	55 sq. mi.

In the western part of Terrebonne Parish that is subject to fresh water discharge from the Atchafalaya River, 39 square miles of brackish marsh were changed to intermediate and fresh marshes.

A more comprehensive analysis of habitat changes in Terrebonne Parish has been completed subsequent to Chabreck's studies (Wicker et al. 1980). The narrow natural levees provide the only dry land suitable for development and agricultural purposes. Nearly all of the levee hardwood forests originally covering Terrebonne Parish have been cleared for residential use and more recently as a result of energy related activities, commercial and industrial development. The dynamic growth of oil and gas exploration during the last three decades has placed an entirely different demand on the relatively few chunks of high-and-dry real estate (MDPR). The need for onshore support bases, platform fabrication and pipe supply yards and ship construction and service yards have increased exponentially (MDPR). The extensive second growth cypress-tupelo swamps have grown significantly since they were clear-cut primarily for the harvest of virgin cypress around the turn of the century.

The most obvious and more serious change has been land loss (Table IV-3). This phenomenon is more pronounced in the south and southeastern portions of the parish and is associated with a number of natural and man-influenced factors.

4.1.1.4 Soils. Terrebonne Parish soils were derived from slightly acid to moderately alluvium parent material deposited by the Mississippi River and Red River. These alluvial sediments were left by the distributary streams of several deltas of the Mississippi River. The oldest delta deposits have been buried, in part, by deposits from successively younger deltas.

The alluvium was derived from widely separated and different geologic sources. The sediments came from the phosphatic soils of the Tennessee, from the limestone soils and limestone of the upper Mississippi River Valley, and from the Permian "Red Beds" of Texas and Oklahoma. By comparing the chemical composition of the soils and colloids of the Mississippi River bottom, it is concluded that most of the alluvial materials come from the eastern slopes of the Rocky Mountains and from the Great Plains area.

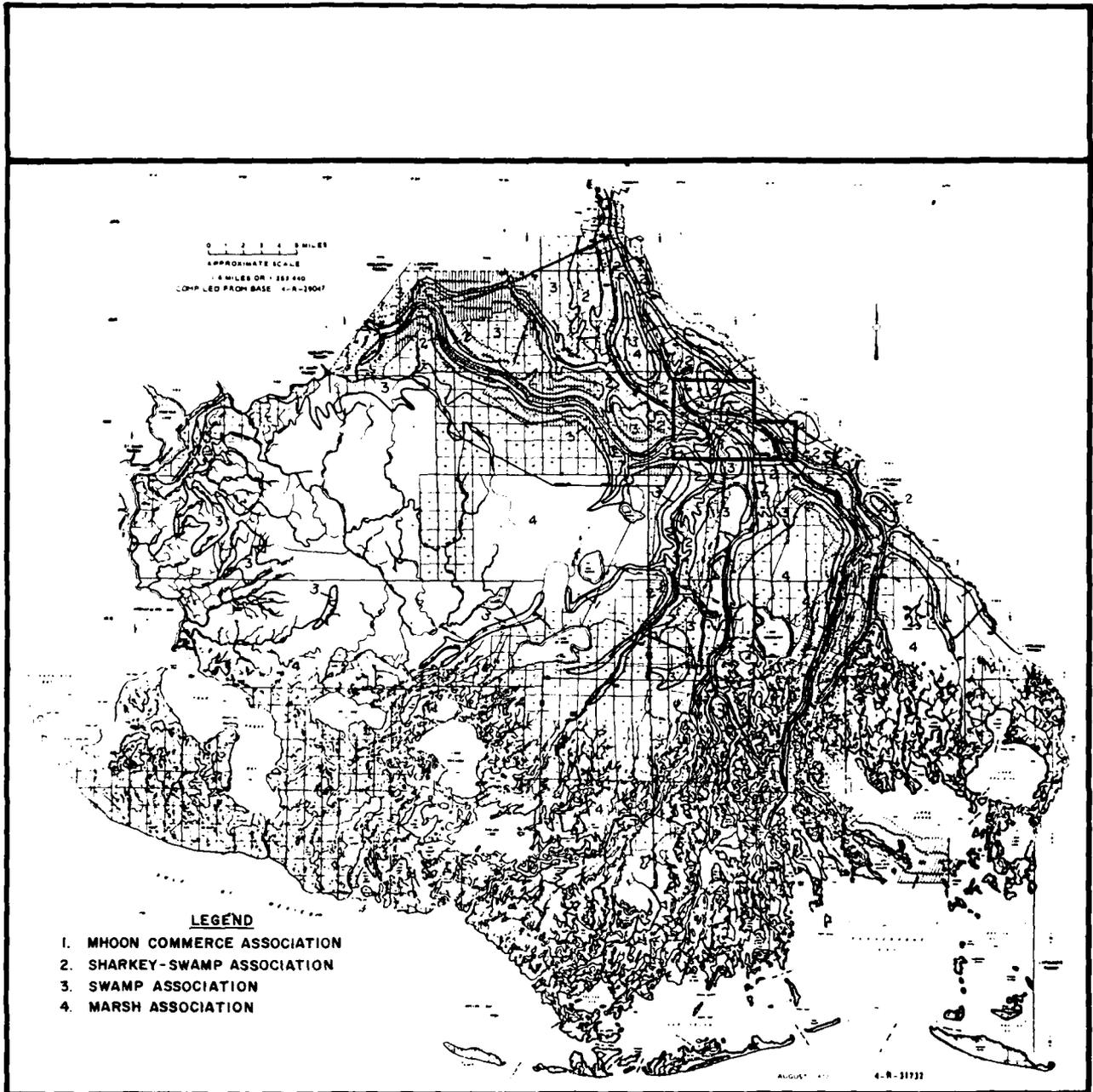
Silt loam and silty clay loam were deposited on the natural levee ridges that parallel the streams; clay and silty clay sediments were left on the back-swamp borders of the ridges in areas of marsh and swamp (Figure IV-5). Table IV-4 lists soil types occurring within each proposed forced drainage project. Table IV-5 lists soil types within each habitat type.

Appendix A describes the four major soil associations occurring in Terrebonne Parish with detailed descriptions of representative soil series, types and phases occurring in project areas.

TABLE IV-3. Terrebonne Parish: Natural and Man-Influenced (Direct) Changes in Habitat Between 1955 and 1978

"FUNCTIONAL" HABITATS	1955 (Acres)	% of Parish	1978 (Acres)	% of Parish	Change in Habitat(Acres)	% Change 1955-1978
1. DEVELOPED						
a) Natural	N.A.	-	N.A.	-	N.A.	-
b) Man-influenced	11,613.0	0.9	20,078.0	1.5	+6,465.0	+0.6
2. AGRIL/PAST./GRASS.						
a) Natural	N.A.	-	N.A.	-	N.A.	-
b) Man-Influenced	57,645.0	4.3	55,556.0	4.1	-2,089.0	-0.2
3. FORESTS						
a) Natural	17,928.0	1.3	22,560.0	1.7	+4,632.0	+0.3
b) Man-Influenced	966.0	0.1	2,766.0	0.2	+1,799.0	+0.1
4. SWAMPS						
a) Natural	112,397.0	8.3	94,255.0	7.0	-1,814.0	-1.3
b) Man-Influenced	N.A.	-	N.A.	-	N.A.	-
5. SCRUB/SHRUB						
a) Natural	114.0	0.0	12,960.0	1.0	+12,646.0	+1.0
b) Man-Influenced	3,147.0	0.2	10,792.0	0.8	+7,650.0	+0.6
6. FRESH MARSH						
a) Natural	304,938.0	22.7	177,812.0	13.2	-127,124.0	-9.4
b) Man-Influenced	1,415.0	0.1	1,796.0	0.1	+382.0	-0.0
7. NONFRESH MARSH						
a) Natural	303,806.0	22.6	297,002.0	22.0	-6,804.0	-0.5
b) Man-Influenced	N.A.	-	1,901.0	0.1	+1,901.0	+0.1
8. WATER						
a) Natural	525,698.0	39.0	631,260.0	46.9	+105,562.0	+7.8
b) Man-Influenced	5,953.0	0.4	17,100.0	1.3	+11,148.0	+0.8
9. BEACH/JETTY/REEF/BAR						
a) Natural	1,515.0	0.1	1,279.0	0.1	-236.0	-0.0
b) Man-Influenced	N.A.	-	7.0	0.0	+7.0	+0.0
TOTAL PARISH AREA:	1,347,128.0	100.0	1,347,126.0	100.0		

N.A. - NOT APPLICABLE



**TERREBONNE PARISH-WIDE FORCED DRAINAGE
 ENVIRONMENTAL IMPACT STATEMENT**

TERREBONNE PARISH SOIL ASSOCIATIONS

T. BAKER SMITH & SON, INC.
 CIVIL & CONSULTING ENGINEERS,
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 HOUMA, LOUISIANA

U.S. ARMY ENGINEER DISTRICT
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FIGURE IV-5

TABLE IV-5. Soil Types Within Different Habitats

Soil Type Mhoon-Commerce	Marsh Types		Cypress-Type/Swamp	Wet Bottomland Hardwoods	Other Uplands
	Saline	Fresh			
Ba					X
Sd					X
Ma					X
Mh					X
Ca					X
Cb					X
Cd					X
Ce					X
Rd					X
Mf					X
Sharkey-Swamp					X
Se				X	
Mk		X			
Cc					X
Me					X
Mg				X	
Mc					X
Sg			X		
Sh			X		
Swamp					
Mc			X		
Sg			X		
Sh			X		
Sk			X		
Sm			X		
Marsh					
Mb					X
Bb	X				
Bc	X				
Id	X				
Be	X				
Fa					
Fb					
Fc					X
Fd					X
Fa					X
Sa					X
Sb					X
Sc					X
Sf					X

4.1.1.5 Hydrological

4.1.1.5.1 Introduction. This section provides a hydrological characterization of Terrebonne Parish by functional habitat. It is an essential step in developing a framework for the systematic evaluation of the effects of engineering projects on hydrological processes.

Hydrological processes clearly are not constrained by political boundaries; to understand these processes and their effects it is necessary to consider the political entity in the context of relevant geophysical considerations. This approach leads to the development of hydrologic units (Fig. IV-6) to describe certain aspects of the physical environment of coastal Louisiana (Gagliano et al. 1970). Each unit shown in Fig. IV-6 is a natural catchment basin which is open at the lower or Gulf end.

Hydrologic Unit V of which Terrebonne Parish is an integral part is bounded on the east by the levees of Bayou Lafourche and the Mississippi River, on the west and north by the Avoca Island, East Atchafalaya Basin, Morganza Floodway and Mississippi River levees and on the south by the Gulf of Mexico. Hydrologic Unit V is further subdivided later in this section for the purpose of water balance computations and analysis.

4.1.1.5.2 Study Procedure. The hydrological assessment consisted of two major tasks:

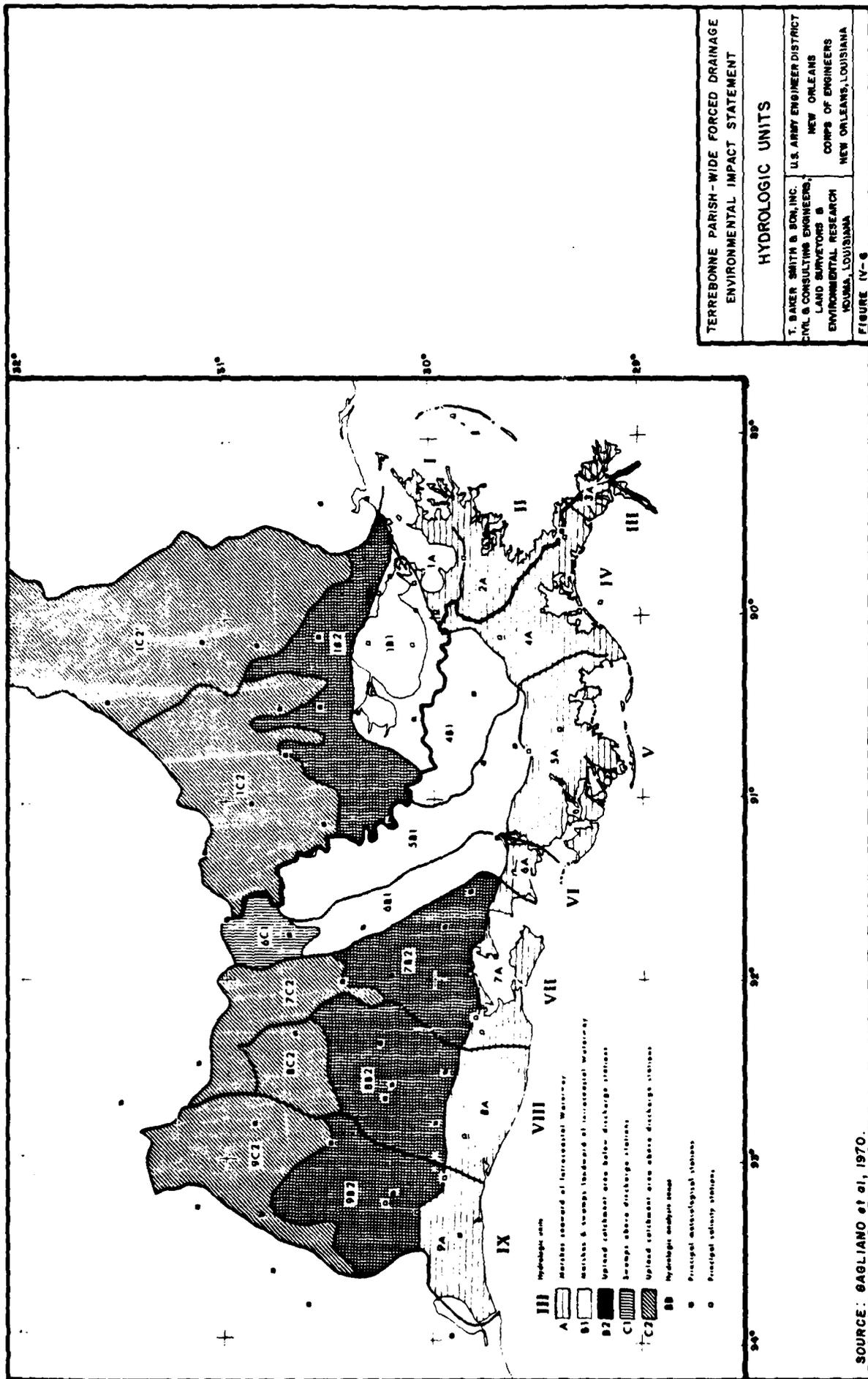
- 1) Literature search for pertinent information and relevant data.
- 2) Preliminary assimilation and analysis of selected data sets.

Physical parameters investigated included water level, salinity, precipitation, evaporation and air temperature.

A crucial parameter in hydrologic studies is flow or discharge through principal watercourses of a drainage basin, which is, of course, a central element in the overall water balance. Presently there is no program operating to systematically gauge the discharge of all the major bayous and canals which drain the area; therefore, we have employed the use of standard water flow models to simulate natural conditions.

Low land elevations south the Gulf Intracoastal Waterway (GIWW) make this area susceptible to a periodic inundation by Gulf waters driven by hurricanes and other major storms. Because of the potential flood hazard it has not been prudent for appropriate agencies to establish permanent meteorological monitoring stations in the southern part of the basin. We therefore relied on data from meteorological stations in the upper portion of the basin to infer basin-wide processes.

4.1.1.5.3 Drainage Pattern. Terrebonne Parish is transected by more than 140 named bayous and canals (T. Baker Smith & Son, Inc. 1979). These watercourses carry and distribute runoff water generated both by local precipitation and by rainfall falling in the drainage basin to the north. Not coincidentally, the four most important bayous in terms of water storage capacity are those which have experienced the most cultural development upon their levees. These include Bayous Grand Caillou,



Dularge, Terrebonne and Petit Caillou (Fig. IV-7), the dimensions of which are given in Table IV-6. The Houma Navigation Canal (Fig. IV-7), a relatively recent man-made channel (Table IV-6), is also an important conduit for distributing runoff water. Secondary water routes, (Table IV-7) although not as important as the five primary channels, may be expected to carry significant quantities of water during those times of the year when there is an excess of precipitation.

The majority of the bayous and canals (Tables IV-6 and IV-7) are distinguished by the fact that they trend generally north-south; thus they carry water from the higher elevations in the northern part of the parish toward the marshes and coast. A notable exception to the general trend is the Gulf Intracoastal Waterway (GIWW) which runs east-west, partitioning the parish in a north-south direction. Approximately 75% of the parish area is Gulfward of the GIWW. The GIWW exerts a significant influence on the local hydrological regime acting as it does as a type of manifold, receiving much of the water from the upstream catchment basin at one point and distributing it to various bayous which intersect along its length.

4.1.1.5.4 Hydrological Characterization of Habitats.

Hydrologically it is convenient to divide the coastal environment into wetlands depending upon whether surface water is present or absent throughout a substantial part of the year. The non-wetland category is comprised of two specific physical-biological environment types: (1) levee hardwood forest and (2) agricultural and residential, both of which are included in the other upland habitat category. The nonwetland habitats generally lie above normal tide levels but may be subject to occasional inundation from extreme natural events such as storm surges and abnormally high amounts of rainfall.

The wetland category includes: (1) saline marsh; (2) brackish marsh; (3) intermediate marsh; (4) fresh marsh; (5) cypress-tupelogum swamp; and (6) wet bottomland hardwood forest. The six wetland habitat types occupy approximately 40% of the area of the parish. The saline, brackish, and intermediate marsh types, together with the principal water courses and the extensive open water areas of the southern portion of parish, delineate an important estuarine environment.

Estuaries which are characterized by communication with the sea through narrow, restricted entrances and by relatively low tide ranges are frequently referred to as bar-built estuaries (Pritchard 1952). The Terrebonne-Timbalier Bay complex clearly is of this type. The bay-lake complex in the southwestern part of the parish may be classified as a bar-built estuary during that period of the year when the area exhibits estuarine characteristics. The proximity of this area to the Atchafalaya River outflow exerts a strong influence on the adjacent marshland, debouching large quantities of water and sediment into the marshes during periods of high river flow.

The main independent and controlling variables in estuaries are tides at the sea surface and freshwater from stream flow and land runoff. The geomorphology of the land surface and the nature of the geological materials which form the substrate over which the water flows determine the boundary conditions of the system.

TABLE IV-6. Primary Drainage Routes in Terrebonne Parish (from T. Baker Smith & Son, Inc., 1979)

Name	Length (mi.)	Width (ft)	Depth (ft)	Storage	Vol (Acre-ft)
Bayou Dularge	35.5	80	4.0		1,376
Grand Bayou Dularge	4.9	1400	20.0		16,720
Bayou Petit Caillou	35.5	60	4.5		1,161
Houma Navigation Canal	35.3	300	8.0		10,280
Bayou Terrebonne	35.9	125	7.5		4,080
Bayou Grand Caillou					37,280

Table IV-7

Secondary Drainage Routes in Terrebonne Parish

<u>Name</u>
Avoca Island Cutoff Bayou Drainage Channel
Bayou Big Parasol
Bayou Black
Bayou Charles Theriot
Bayou Chauvin
Bayou Chene
Bayou Chine
Bayou Cocodrie
Bayou Colyell
Bayou Copasaw
Bayou de l'Ouest
Bayou Grand Sale'
Bayou Ne Touche Pas
Bayou Penchant
Bayou Pointe-aux-Chenes
Big Carencro Bayou
Big Misale Bayou
Crooked Bayou
Dog Lake Bayou
Falgout Canal
Four Island Bayou
Four Point Bayou
Grand Pass des Ilettes
Hackberry Bayou
Little Misale Bayou
Locust Bayou
Mound Bayou
Oyster Bayou (lat. 29°09' long. 90°43')
Pass de Ilse
Pass de Ilettes
Post Bayou
Quitman Bayou
Taylor's Bayou
Trinity Bayou
Turtle Bayou
Victor's Bayou

Sea tides are the result of gravitational forcing by the moon, sun and planets. Because the motions of these bodies are well known, their tide-producing effects can be calculated and the resulting tides predicted with some accuracy. Superimposed upon this predictable behavior are the effects of meteorological conditions which, for the most part, are random and, therefore, are not amenable to rigorous prediction. These latter effects frequently are the most important from a practical point of view. An excellent summary of tidal mechanics, with emphasis on details which are relevant to the behavior of estuarine circulation, is presented by McDowell and O'Connor (1977).

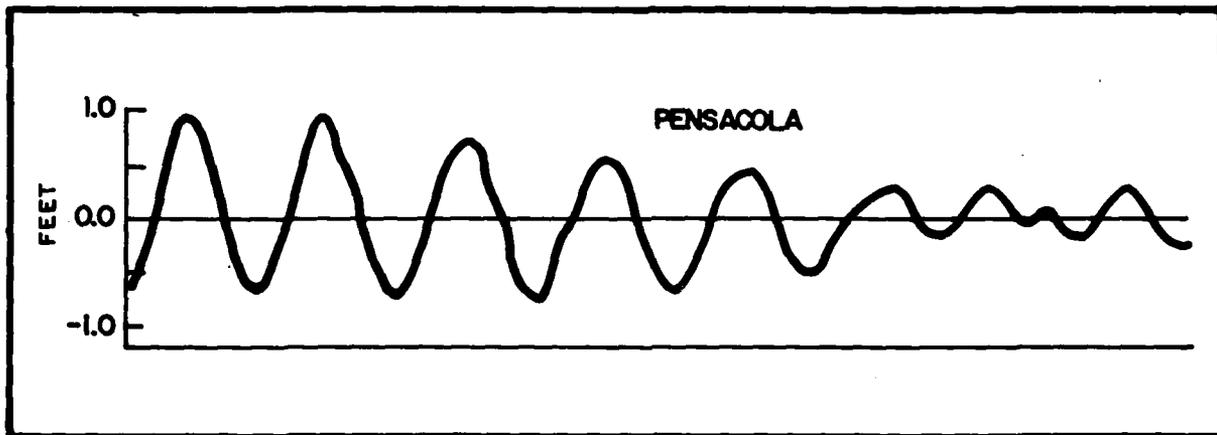
Changes both in the wind and the barometric pressure may give rise to perturbation in the normal tidal cycle. This is true not only for the heights of high and low water but also for the times of occurrence. In shallow estuaries of the northern Gulf the effects of wind on the tide normally are greater than the direct effects of barometric pressure (Marmer 1954). Moreover, Kjerfve (1972) found wind effects to be more important than tidal effects in controlling the surface dynamics of small marsh lakes and their interconnecting channels.

Tides in the Gulf of Mexico are principally diurnal, i.e. one-high and one-low water each day; the range of the tide everywhere is modest. The daily cycle is shown clearly in tide records from Pensacola, FL (Fig. IV-8) and Caminada Bay, LA (Fig. IV-9). Tides entering Barataria Bay, immediately to the east of Terrebonne Parish, have an annual range of about one foot but may be as much as three feet (Byrne *et al.* 1976). At Caminada Bay during a three-week period in July 1972, tidal ranges varied from a maximum of about 1.5 feet to a minimum of about 0.3 feet (Fig. IV-9). Tidal conditions in Terrebonne-Timbalier Bays should be similar to those experienced in Barataria Bay.

Storm surges associated with hurricanes or other major tropical storms are capable of locally elevating coastal water levels to more than +11 feet NVGD. Winds blowing from the continent to the Gulf or from west to east can produce a coastal sea level depression; records indicate levels of less than -1 foot NVGD. The change in mean elevation shown in the Caminada Bay record is a clear indication of meteorological forcing. Tidal effects, i.e., diurnal water level fluctuations, are seen as far inland as the Gulf Intracoastal Waterway at Houma.

Water level is defined as the mean elevation of the water surface when surface gravity wave effects have been averaged out. To provide meaningful data, elevations of water level (tide) gauges are referenced to a standard elevation or datum. There are two reference datums in use along the Gulf Coast of the United States. The most common, mean sea level (MSL), is defined as the average height of the surface of the sea for all stages of tide over a 19-year period. In North America, NVGD has now been supplanted by the National Vertical Geodetic Datum (NVGD) as the primary reference level. Mean low Gulf (MLG), which is 0.78 feet below NVGD, is also used along the Gulf of Mexico.

The large fluctuations in water level associated with transient local weather are of relatively short period, on the order of a few hours to a few days. There is another more subtle change in water level which occurs on a seasonal basis. The seasonality is primarily a consequence of the biannual variability in the curl of the wind stress over the entire



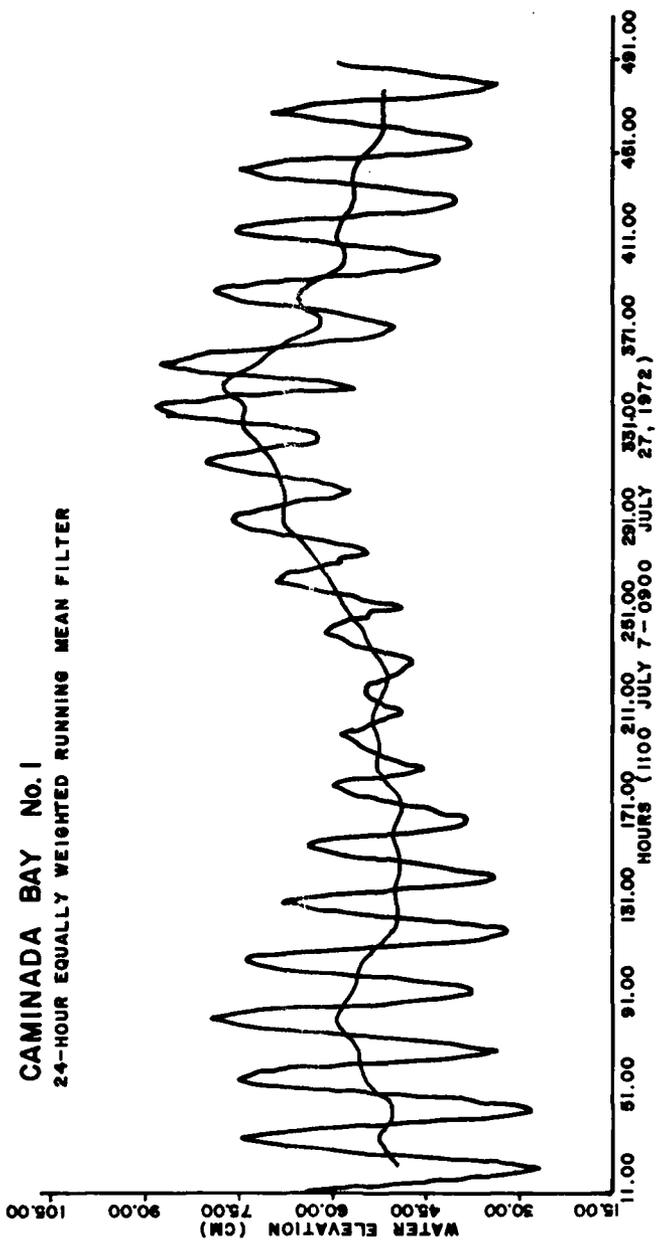
**TERREBONNE PARISH-WIDE FORCED DRAINAGE
ENVIRONMENTAL IMPACT STATEMENT**

DAILY TIDE CYCLE (PENSACOLA)

T. BAKER SMITH & SON, INC.
CIVIL & CONSULTING ENGINEERS,
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ENVIRONMENTAL RESEARCH
HOUMA, LOUISIANA

U.S. ARMY ENGINEER DISTRICT
NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

FIGURE IV-8



TERREBONNE PARISH-WIDE FORCED DRAINAGE ENVIRONMENTAL IMPACT STATEMENT	
DAILY TIDE CYCLE (CAMINADA)	
T. BAKER SMITH & SON, INC. CIVIL & CONSULTING ENGINEERS, LAND SURVEYORS & ENVIRONMENTAL RESEARCH HOUMA, LOUISIANA	U.S. ARMY ENGINEER DISTRICT NEW ORLEANS CORPS OF ENGINEERS NEW ORLEANS, LOUISIANA

FIGURE IV-9

Gulf of Mexico (Sturges and Blaha 1976). This long-period change thus is a result primarily of the regional wind field rather than localized wind patterns. The effect of the regional variability in wind stress curl is shown clearly in monthly averaged water level data from three stations along the northern Gulf of Mexico shoreline (Fig. IV-10).

In the seasonal progression shown in Figure IV-11, water level is lowest during winter, reaches a vernal peak in April-May, goes through a mid-summer minimum, and attains its highest levels in September-October. The range of water levels from the winter low to the autumn high is on the order of 1.0 foot.

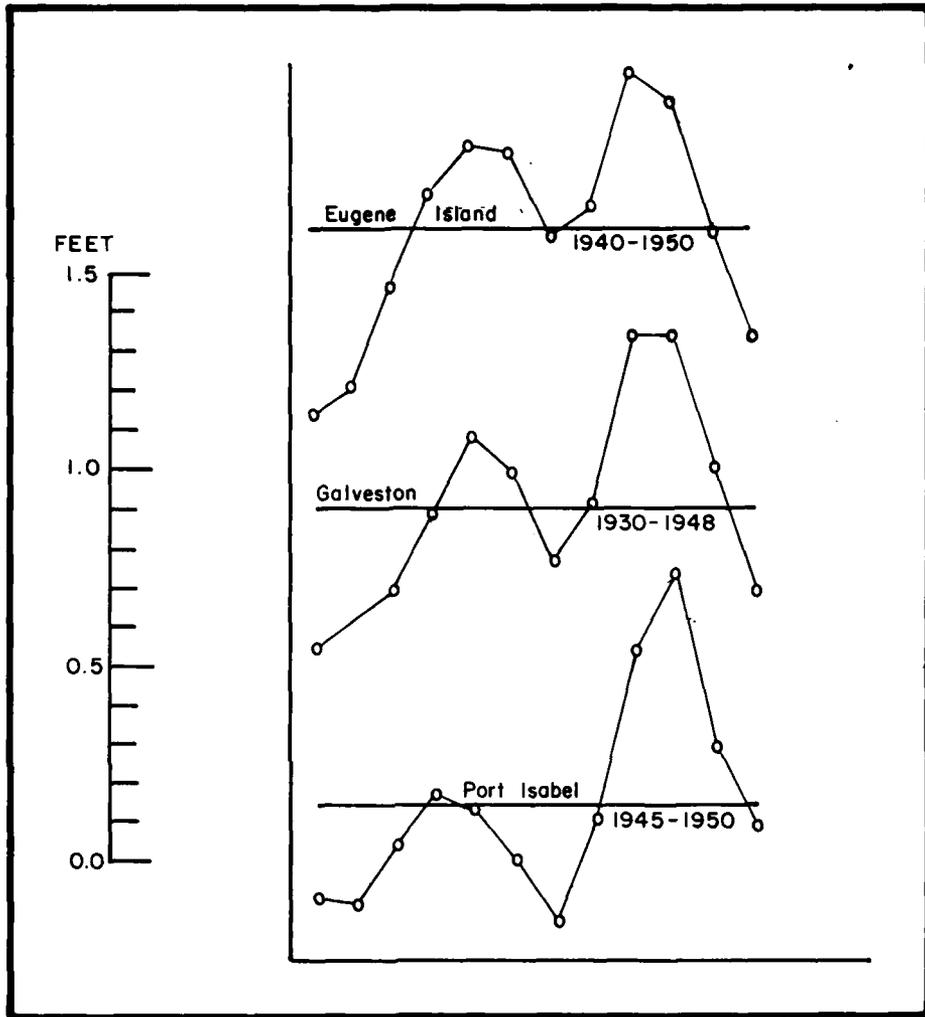
In temperate latitudes, the normal annual trend is a monotonic rise of water level from spring to autumn, the highest levels coinciding with the peak in heat storage of the upper layers of the ocean. The summer low, which is characteristic of a great number of coastal tidal stations from the Gulf of Mexico (Sturges and Blaha 1976), thus is unusual. The anomalous summer behavior of Gulf of Mexico water levels were discussed by Whitaker (1971). The relatively rapid rise from the summer low to the autumn peak apparently is due to an increase in surface wind stress in September coupled with the expansion of the water column which accompanies the increase of stored heat (Surges and Blaha 1976).

Some effects of seasonal climatic variations on estuary water levels are clearly shown in Figure IV-12 where seven mean water level values are plotted for Bayou Petit Caillou at Cocodrie, Bayou Lafourche at Leeville and the GIWW at Houma. As might be expected, water level at Houma is always higher than the levels at either Leeville or Cocodrie which gives a slope of the correct sense and a seaward driven hydraulic gradient flow in all months.

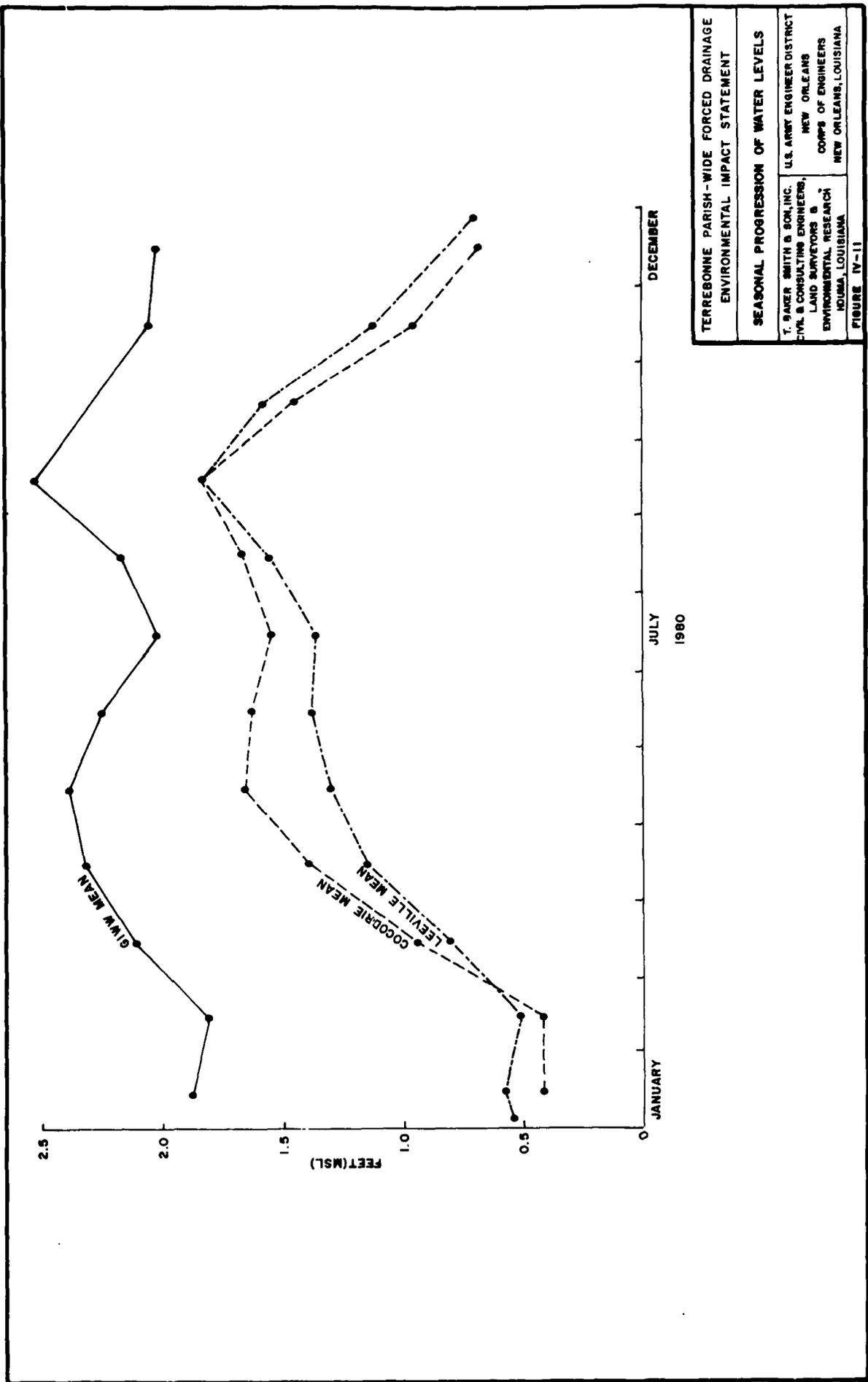
The effect of high Gulf water levels in April and September are reflected in the water levels at Houma and Cocodrie; at Leeville only the September peak is prominent. From March through September, Cocodrie is higher than Leeville. This period corresponds to the time when winds over the area are generally southeasterly. Under the influence of such winds, water would tend to accumulate and pile up along the western boundaries of the estuarine zone. Winds alone thus could account for the trend of the observed water slope which is upward toward Cocodrie. The maximum difference in water elevation occurs in April-May coinciding with peak runoff; therefore, basin precipitation plays an important role in determining the magnitude of the water slope and in turn the intensity of pressure gradient associated flow.

The importance of precipitation to vernal water levels is also indicated in Figure IV-12 where mean monthly levels for 1973 (a high water year) and for 1977 (a low water year) are plotted for the three aforementioned stations. At all stations spring water levels in 1973 were higher than in 1977. In the fall, however, there was little or no apparent difference in levels between the two years.

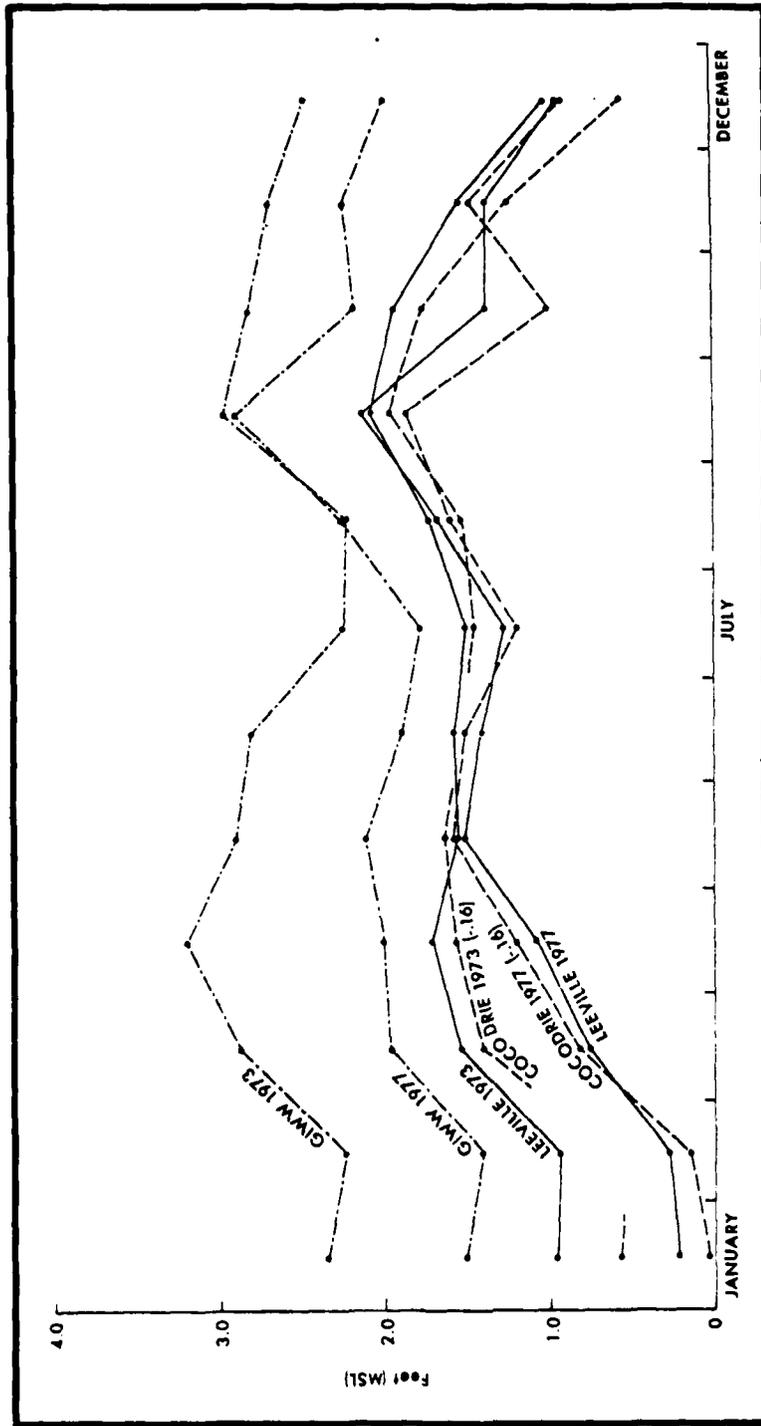
In September, Cocodrie and Leeville water levels approach each other (Fig. IV-12). It is at this time of year that the nearshore Gulf circulation becomes less a function of oceanic effects and more of continental weather patterns. During the September transition period the cross-basin water slope vanishes.



TERREBONNE PARISH-WIDE FORCED DRAINAGE ENVIRONMENTAL IMPACT STATEMENT	
MONTHLY AVERAGED WATER LEVEL DATA	
T. BAKER SMITH & SON, INC. CIVIL & CONSULTING ENGINEERS, LAND SURVEYORS & ENVIRONMENTAL RESEARCH HOUMA, LOUISIANA	U.S. ARMY ENGINEER DISTRICT NEW ORLEANS CORPS OF ENGINEERS NEW ORLEANS, LOUISIANA
FIGURE IV-10	



TERREBONNE PARISH-WIDE FORCED DRAINAGE
 ENVIRONMENTAL IMPACT STATEMENT
 SEASONAL PROGRESSION OF WATER LEVELS
 T. BAKER SMITH & SON, INC. U.S. ARMY ENGINEER DISTRICT
 CIVIL & CONSULTING ENGINEERS, NEW ORLEANS
 LAND SURVEYORS & COMPS OF ENGINEERS
 ENVIRONMENTAL RESEARCH HOUMA, LOUISIANA
 NEW ORLEANS, LOUISIANA
 FIGURE IV-11



TERRESONNE PARISH - WIDE FORCED DRAINAGE
 ENVIRONMENTAL IMPACT STATEMENT
 CLIMATIC VARIATIONS AND THEIR EFFECTS
 ON ESTUARY WATER LEVELS
 T. BAKER SMITH & SON, INC. U.S. ARMY ENGINEER DISTRICT
 CIVIL & CONSULTING ENGINEERS, LAND SURVEYORS & NEW ORLEANS
 ENVIRONMENTAL RESEARCH CORPS OF ENGINEERS
 HOUMA, LOUISIANA MOBILE, LOUISIANA
 FIGURE IV-12

The similarity of the Houma and Cocodrie curves to water level hydrographs at other Gulf coastal locations (Fig. IV-10) suggests that both stations are strongly influenced by conditions in the Gulf. It is interesting to note that Houma appears to exhibit more Gulf influence than does Leeville, which is more than 20 miles nearer the coast. The correlation of coastal water levels and those at Houma in the GIWW appear to be an effect of the Houma Navigation Canal. Salinity variations, to be discussed subsequently, permit the same interpretation.

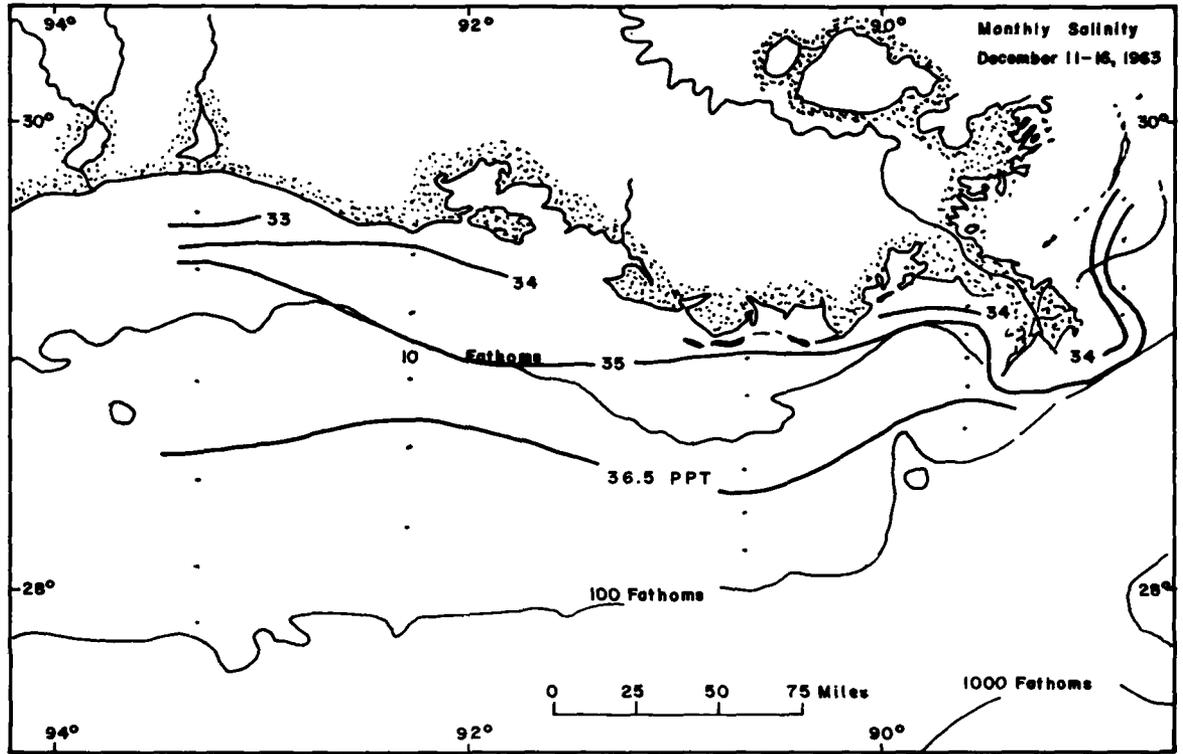
The second variable in the estuarine hydrology problem is the input of fresh water by direct precipitation and by the flow of rivers and streams. The equilibrium of an estuary, i.e. the tendency to remain unchanged with time, will prevail only if a balance is struck between the quantities of water, solids and soluble salts. This balance represents the familiar principle of conservation of mass that is so important to estuarine behavior.

In an estuarine system that is in equilibrium, rate of fresh water outflow, averaged over a few weeks, must equal the rate of inflow averaged over the same time period. In shallow, bar-built estuaries, direct rainfall, evaporation and soil infiltration may be as important to the water balance of the area during much of the year as river and stream flow. The addition of fresh water to the coastal zone either as rainfall or river flow tends to lower the salinity and thus the density of coastal waters. During high spring stages of the Mississippi River, salinities may not approach typical Gulf of Mexico values for as far as 20-30 miles offshore from the river mouth (Nowlin 1972, Fig. I-18). The net addition of fresh water and the effect of this water on reducing densities both tend to increase coastal water level. Evaporation removes water directly and by increasing salinity, increases density. Thus both evaporation and soil infiltration tend to lower coastal water levels.

Salinity is one of the most important parameters for characterizing wetland habitats because the quantity of salts present in the water has a controlling influence on the flora and fauna of an area. Although salinity is not totally conservative in the coastal zone, it is sufficiently so to be of value in estimating water replacement times and for inferring circulation patterns. Both processes have hydrological implications.

Salinity is defined as the weight in grams of the dissolved inorganic matter in 1 kg of seawater after all bromide and iodide have been replaced by the equivalent amount of chloride and all carbonate converted to oxide (Carritt and Carpenter 1959). The units of this quantity are, of course, dimensionless and are given as parts per thousand (PPT or o/oo). In practice either chlorinity or conductivity is measured and converted to salinity with appropriate mathematic relationships or tables. Ionic composition as well as temperature influence conductivity; thus the conductivity-salinity relationship, which was determined for seawater, must be used with caution in estuarine areas.

The salinity regimes of the coastal wetlands of Terrebonne Parish are strongly influenced by both Mississippi and Atchafalaya River discharges during parts of the year. During periods of low flow, high salinity Gulf water lies close inshore and intrudes into the estuaries (Fig. IV-13).



**TERREBONNE PARISH-WIDE FORCED DRAINAGE
ENVIRONMENTAL IMPACT STATEMENT**

SALINITY GRADIENTS DURING LOW RIVER DISCHARGE

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FIGURE IV-13

When flow in the Mississippi River is great, coastal salinities may be depressed by as much as 15 ppt (Fig. IV-14). Variations of this magnitude are seasonally periodic; the intensity is, of course, a function of river flow. Salinities in the upper portions of the estuaries may be strongly influenced by local precipitation.

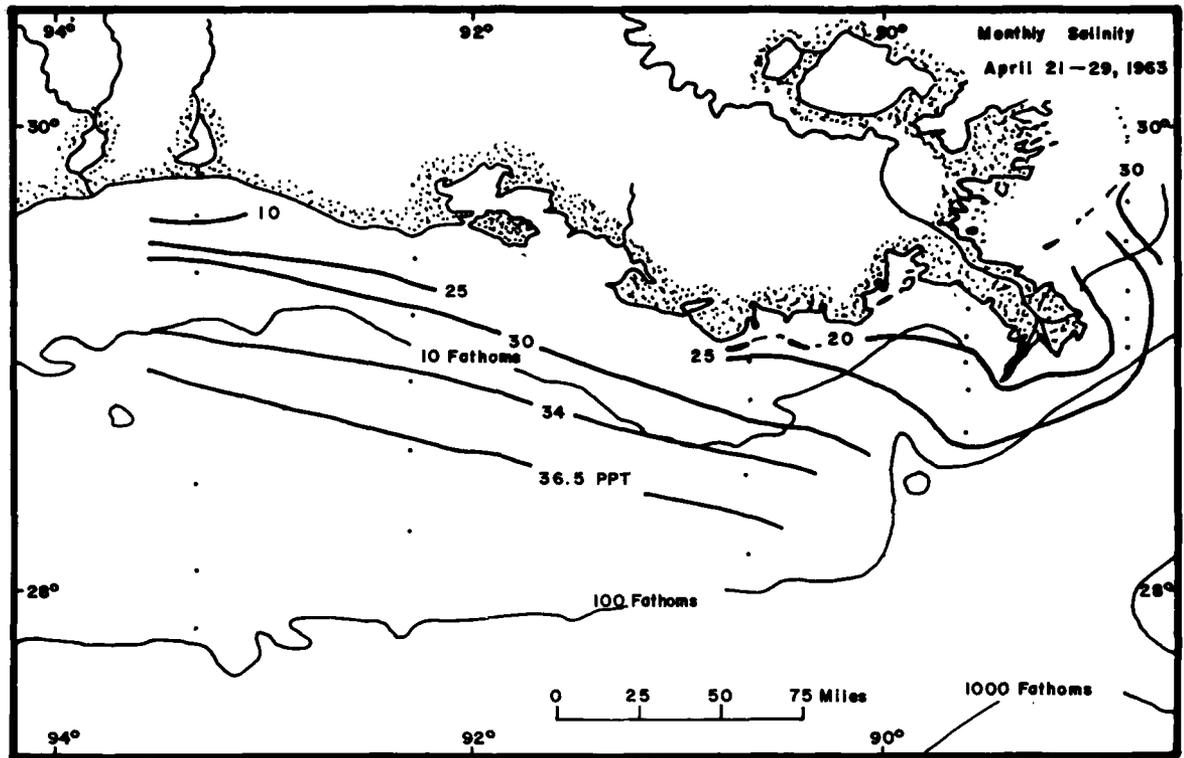
Coastal salinities are also influenced by water levels in the Gulf of Mexico. It has been shown that water levels fluctuate seasonally. The coastal hydrograph (Fig. IV-10) is bimodal with two highs; one is in April and another, the highest, is in September. For a given runoff value, higher coastal water levels permit the higher salinity waters of the Gulf to penetrate farther inland than when water levels are low. During the April high water level period, Mississippi River discharge frequently attains its annual maximum and thus opposes inland movement of saline water. In the fall when Gulf water levels are highest, river and overland runoff is relatively low and salinity in the coastal wetlands generally increases.

Salinity encroachment is primarily caused by two factors: (1) land subsidence (discussed elsewhere) and (2) canal/channel construction within the wetlands. Encroachment as used here implies permanent and essentially irreversible change as opposed to salinity variations which may result from short term perturbations in the local, meteorologic and oceanographic climates.

In Figure IV-15 are shown time-series of mean salinity (chlorinity) for Bayou Grand Caillou at Dulac, Bayou Terrebonne at Bourg, Houma Navigation Canal at Crozier and the GIWW at Houma. The most obvious feature of all the curves is the salinity maximum in August. Although Crozier is more than ten miles farther from the coast than Dulac, salinity values at the two locations are similar. On the other hand, Bourg and Crozier are at comparable distances inland yet mean salinity values at the latter location are about three times greater than at the former. In November, salinity in the GIWW at Houma is higher than at Dulac, 15 miles closer to the coast. Moreover the high at Houma coincides with a high on the Houma Navigation Canal at Crozier; a similar relationship is present in the August values. These observations are consistent with the view that the Houma Navigation Canal is a primary route for saltwater moving landward and thus exacerbates intrusion of saltwater into the marshlands near the head of the estuarine zone.

The estuarine system is closed finally by specifying the conditions at the boundaries. Vertical boundaries where uplands and wetlands meet have a controlling influence on water movements and circulation patterns and has been indicated earlier on water levels and water surface slopes. The bottom, horizontal boundary, however, is of equal or greater importance for it is along the bottom where friction dissipates most of the energy of the flow. A rough bottom dissipates greater quantities of energy than a smooth bottom for a given flow velocity. In this regard the vegetated marshes are extremely important tidal energy sinks.

The non-wetland habitats, i.e., levee hardwood forest, wet bottomland hardwood forest and agricultural and residential, affect local hydrology because of their runoff or infiltration characteristics or potential.



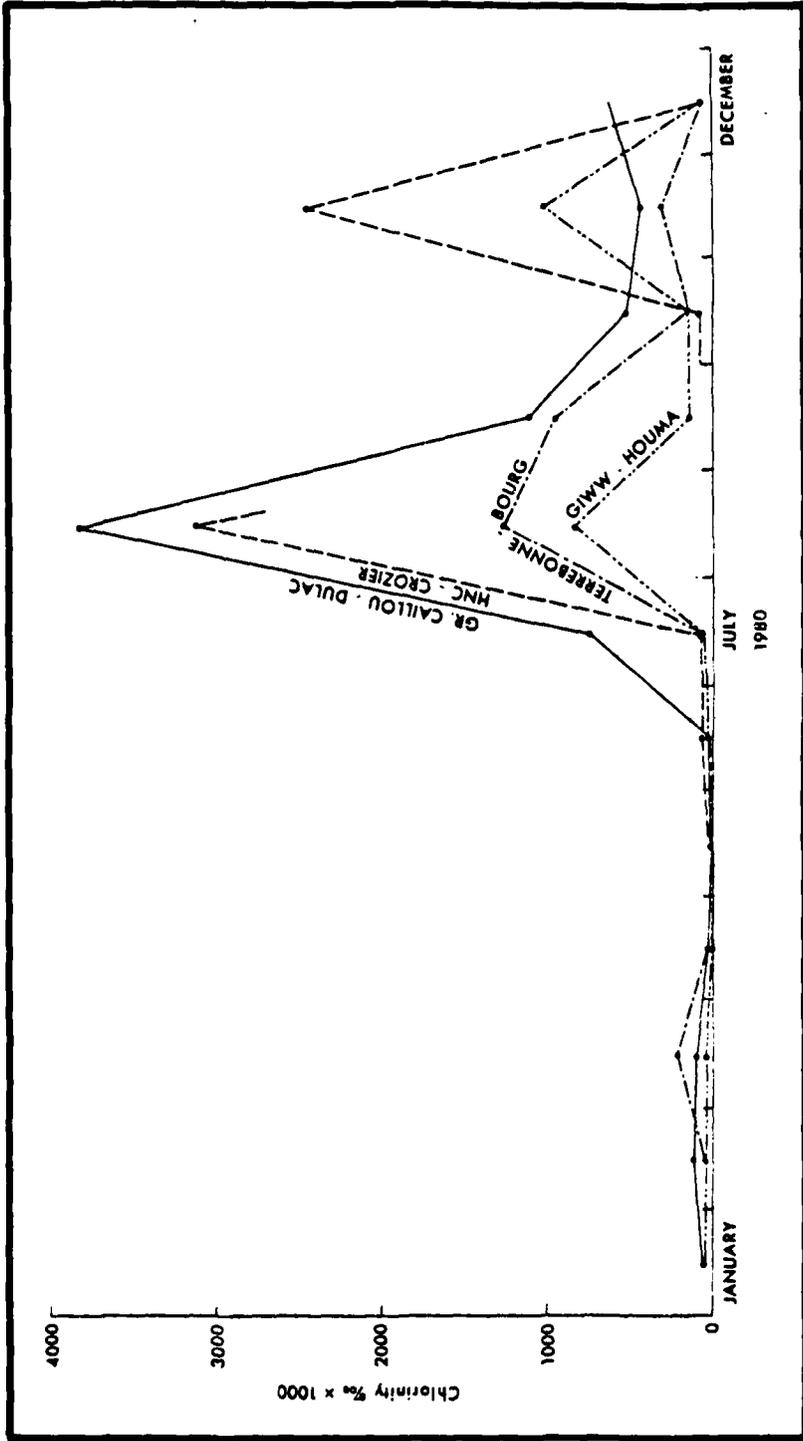
**TERREBONNE PARISH-WIDE FORCED DRAINAGE
ENVIRONMENTAL IMPACT STATEMENT**

SALINITY GRADIENTS DURING HIGH RIVER DISCHARGE

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FIGURE IV-14



TERREBONNE PARISH - WIDE FORCED DRAINAGE ENVIRONMENTAL IMPACT STATEMENT

MEAN SALINITY LEVELS FOR MAJOR TERREBONNE DRAINAGE WATERWAYS

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 HOUMA, LOUISIANA HOUMA, LOUISIANA

FIGURE IV-16

4.1.1.5.5 Water Budget. Hydrologically the Terrebonne Basin can be generally divided into two parts. The upper section consists of the Lake Verret/Palourde sub-basin which encompasses approximately 1,330 square miles. The lower sub-basin (approximately 2,000 sq. mi.) is composed primarily of Terrebonne Parish and is roughly separated from the upper sub-basin at the Assumption Parish line.

The primary hydrological interconnections between the two sub-basins are Bayou L'Ouse, Bayou Black and the GIWW. The sub-basins are also connected by vast wetlands and small bayous which permit interconnection between the two sub-basins.

The purpose of the water budget approach is to analyze the long-term hydroclimatology of the Terrebonne Basin with particular emphasis upon identifying the hydrologic hazards which impact Terrebonne Parish and the proposed forced drainage units. A water balance model was employed to generate flows within the basin and its various sub-units. Water level data from Terrebonne Basin and tidal data from the coast were also analyzed and combined with flow data to identify various combined hydrological effects.

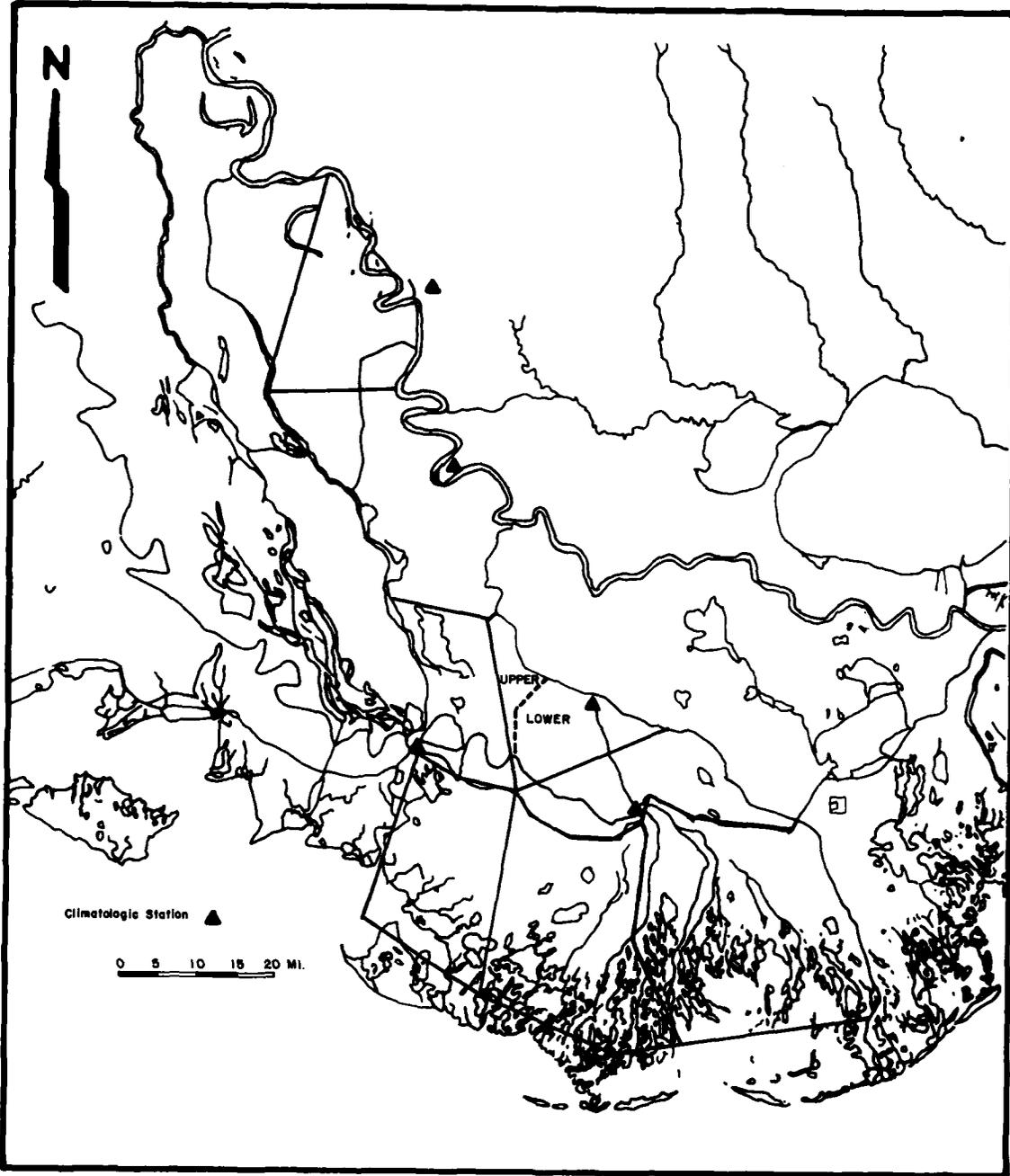
From the analysis it was determined that three separate but often combined hydrological inputs create potential hydrological hazards for Terrebonne Parish. Locally generated runoff within Terrebonne Basin frequently combines with high Gulf tides or back water flooding effects from the Atchafalaya Basin to produce flooding problems. In addition, because of subsidence and rising Atchafalaya River levels these hydrological hazards will likely increase in severity through time.

In order to calculate local runoff due to rainfall within Terrebonne Basin and its various sub-basin units, it is necessary to determine rainfall and temperature distribution in the basin. Six climatological stations are located within or around the fringes of the basin (Fig. IV-16). No climatological stations (except for Grand Isle) are currently in operation south of Houma.

The climatological data base for this analysis consists of 360 observations of monthly temperature and precipitation from each of the six stations during the period 1951-1980. The influence of each climatic station upon the basin as a whole was determined by constructing Thiessen polygons covering the basin (Fig. IV-16). Table IV-8 lists the area of each polygon and summarizes the average monthly temperature and rainfall regime for each station. Water balance components were computed for each Thiessen polygon as part of the analysis (Appendix B, all appendices were published only in the Draft EIS and may be secured from the New Orleans District).

Evaporation pan data measured at Baton Rouge and Houma were also used in the analysis in order to regionally adjust computation of the water budget program. The average monthly evaporation rate for each station is summarized in Table IV-9. The higher evaporation rates at Baton Rouge are due to its slightly drier, more interior location.

Water level and tide data (Fig. IV-17) from various locations throughout and adjacent to the basin were examined in order to identify periods during which back water flooding or rainfall surplus may have had an impact upon these levels. Table IV-10 summarizes monthly water levels for each station. Because of datum error and differential subsidence,



TERREBONNE PARISH-WIDE FORCED DRAINAGE
 ENVIRONMENTAL IMPACT STATEMENT

CLIMATOLOGICAL STATIONS AND THIESEN
 POLYGONS IN THE TERREBONNE BASIN

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LAND SURVEYORS &	CORPS OF ENGINEERS
ENVIRONMENTAL RESEARCH	NEW ORLEANS, LOUISIANA
HOUMA, LOUISIANA	

FIGURE IV-16

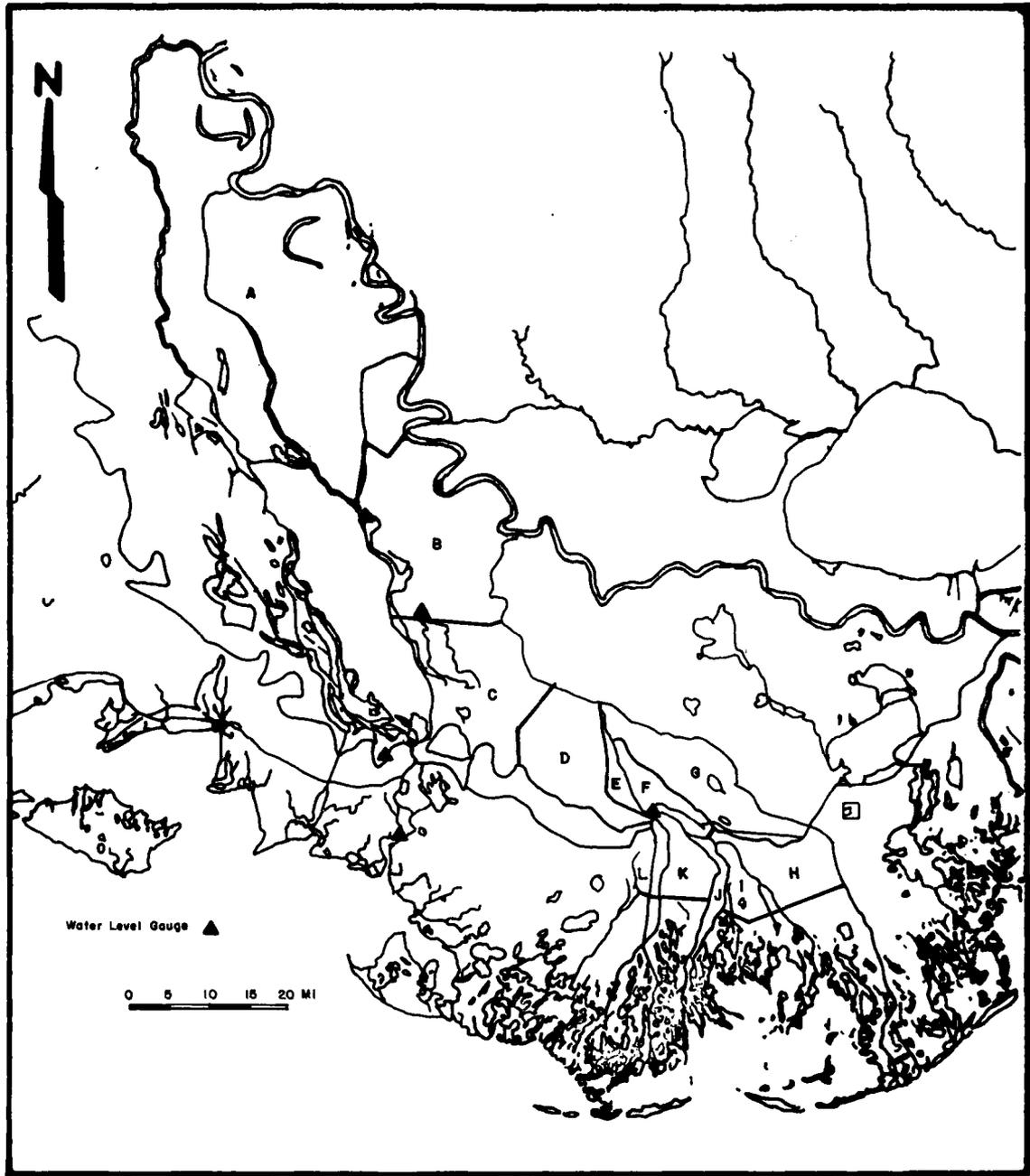
TABLE IV-8. Terrebonne Basin: Climatological Data

Station	Thiesen polygon area (sq. mi.)		J	F	M	A	M	J	J	A	S	O	N	D	Annual Rainfall Totals
Mc-ville	209		48.8 5.1	51.7 5.1	58.9 4.7	67.1 5.3	73.9 5.5	79.5 3.9	81.9 5.2	81.4 4.0	77.0 4.3	66.9 2.9	57.4 4.1	51.2 5.8	55.8
Raton Rouge	428		50.2 4.6	53.01 5.0	59.7 4.6	67.6 5.0	73.9 4.8	79.6 3.1	81.6 7.1	81.0 5.1	77.4 4.4	67.4 7.6	58.1 3.9	52.4 5.0	55.8
Carville	439		52.2 4.8	54.5 4.9	61.1 4.5	68.7 5.0	75.1 5.1	80.2 4.2	82.0 7.0	81.6 5.8	78.4 5.1	69.1 2.7	60.2 4.1	54.4 5.6	58.6
Marion City	587		52.3 4.5	54.6 4.6	61.2 3.9	68.7 4.7	75.1 5.3	80.2 5.1	81.9 8.1	81.6 7.2	78.4 6.2	69.1 3.7	60.2 4.3	54.5 5.1	62.5
Thibodaux	216		53.4 4.5	55.6 5.3	61.8 4.7	69.0 4.9	75.2 6.1	80.6 5.0	82.2 8.7	82.0 6.2	79.1 6.0	70.2 3.2	61.4 4.2	55.7 5.4	65.4
Wouma	1436		53.5 4.8	55.6 4.5	61.9 4.2	69.1 4.6	75.4 5.4	80.3 6.1	82.1 7.9	81.9 6.7	78.9 7.6	70.1 3.2	61.4 4.0	55.7 5.9	63.9

TABLE IV-9. Class A Pan Evaporation (adjusted*): in inches, 1977-1981

Station	J	F	M	A	M	J	J	A	S	O	N	D	Total
Baton Rouge	1.97	2.39	3.65	4.70	5.45	5.92	6.12	5.53	4.61	4.33	2.77	2.13	49.57
Houma	1.80	2.00	3.33	4.27	5.09	5.40	5.24	4.68	4.16	3.69	2.31	1.87	43.84

*.76 pan coefficient applied (M. Kohler, U. S. Weather Bureau Technical paper 37).



TERREBONNE PARISH-WIDE FORCED DRAINAGE ENVIRONMENTAL IMPACT STATEMENT	
WATER LEVEL AND TIDE DATA LOCATIONS	
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FIGURE IV-17	

TABLE IV-10. Terrebonne Basin: Average Monthly Water Levels (feet above M.S.L.): 1970-1980

Station	J	F	M	A	M	J	J	A	S	O	N	D
Bayou Sorrell	3.3	3.1	3.0	3.9	3.8	2.9	2.6	2.3	2.5	2.2	2.4	2.9
Pierre Pass	2.1	2.1	2.4	3.2	2.9	2.5	2.0	1.8	2.1	1.7	1.7	2.0
Bayou Beouf at Amelia	2.1	2.1	2.3	2.8	2.9	2.5	2.1	1.9	2.2	1.8	1.7	2.0
Bayou Black at Gibson	2.0	2.0	2.2	2.7	2.7	2.4	1.9	1.7	2.0	1.7	1.7	2.0
Bayou Black at Greenwood	2.5	2.5	2.6	3.0	3.1	2.8	2.5	2.3	2.7	2.4	2.3	2.5
GIWW at Houma	2.0	1.9	2.1	2.6	2.7	2.4	2.2	2.4	2.7	2.4	2.2	2.1
Sweet Bay Lake	1.8	1.7	2.4	3.0	3.1	2.7	2.2	2.0	2.1	1.8	1.5	1.7
Cocodrie	0.4	0.4	1.0	1.4	1.7	1.6	1.5	1.5	1.8	1.5	1.0	0.7

absolute comparison of water levels between stations is not always reliable. No routine discharge measurements are made within the Terrebonne Basin.

Rainfall surplus and resulting flows generated within Terrebonne Basin were calculated within 12 identified sub-basin units (Fig. IV-17). The units are generally separated from each other by natural or man-made flow impediments such as artificial or natural levees. The division between units B, C, and D is somewhat arbitrary because of the previously mentioned interconnection of flow. The boundary between B and C follows polygon boundaries (Fig. IV-16). The southern boundaries of units H-L were identified in an earlier investigation (Gagliano et al. 1973).

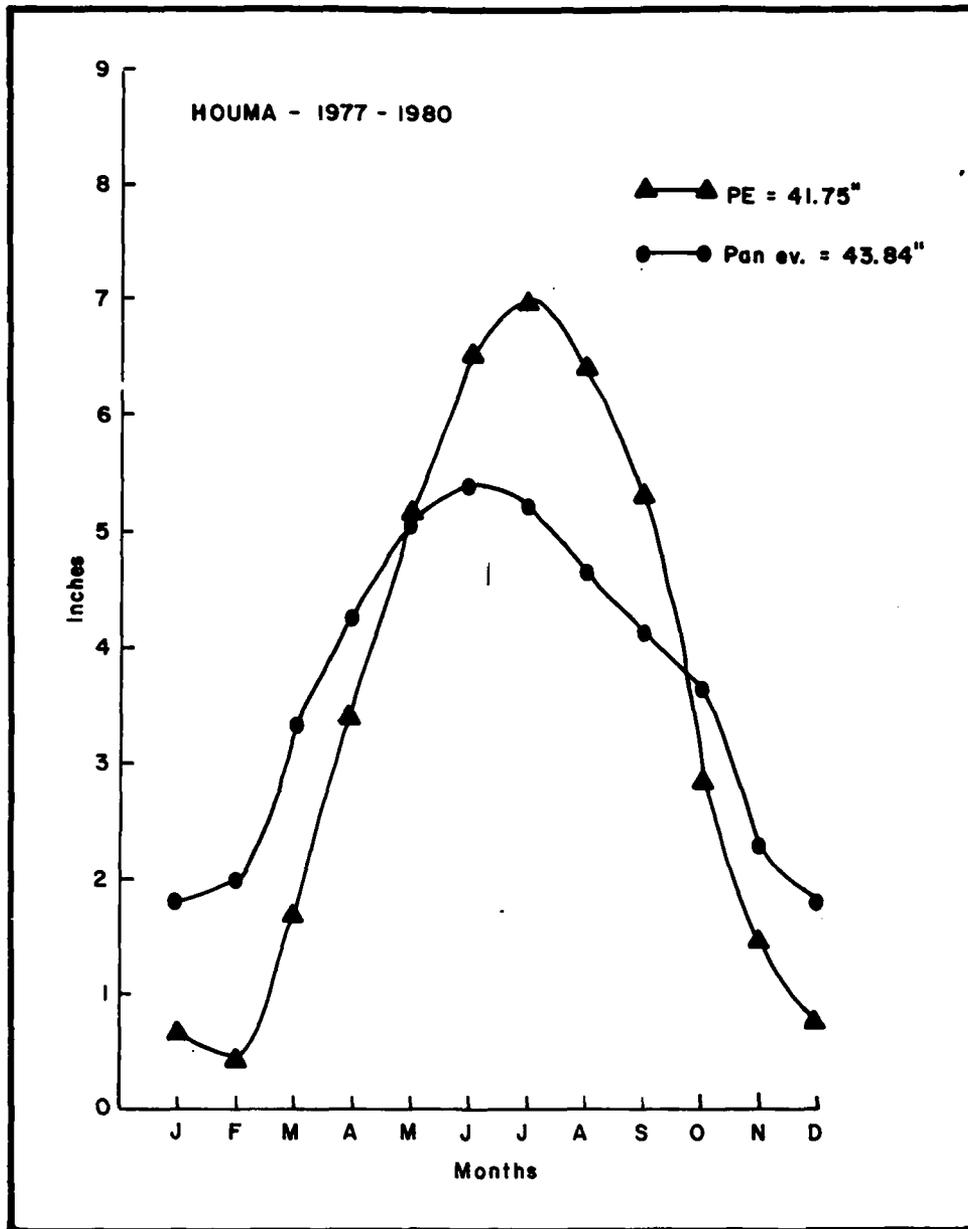
The basic analytical technique used to generate rainfall surplus and flow within Terrebonne Basin was the Thornthwaite and Mather (1955) water budget methodology. The hydroclimatology of coastal Louisiana has been previously studied using this technique by several investigators (Gagliano et al. 1970; Light et al. 1973; Muller 1975).

In the water budget, energy availability and moisture are considered to be dominant climatic factors. Potential evapotranspiration (PE) is calculated mainly on the basis of monthly temperature and adjusted by a radiation or heat index related to latitude (Thornthwaite 1958). Potential evapotranspiration (PE) is considered to be equivalent to evaporation from an open water surface or from a well vegetated, saturated soil surface. The PE was adjusted by developing coefficients derived from evaporation pan data measured at Houma and Baton Rouge as the Thornthwaite Mather method generally under-predicts PE in winter and over-predicts PE in the summer when compared to regionally adjusted pan data (Fig. IV-18).

The above modifications were used to calculate various water budget components including runoff for each of the six climate stations in Terrebonne Basin. Runoff for each sub-basin was computed by statistically smoothing and logging basin surplus from month to month. The final modification to the program involved conversion to volume units and summation of flow for various sub-basin units.

A modified 30-year (1951-1980) monthly water budget was calculated for each of the six climate stations in the basin. Monthly water balance components for Houma are summarized in Appendix B. Water balance components for the other stations are contained in Appendix B.

In the wetland portions of Terrebonne Parish, positive values of precipitation (P) minus potential evapotranspiration (PE) (Appendix B) best represent rainfall surplus. In the upland portion of the parish, soil moisture storage (Appendix B) must be recharged prior to generation of moisture surplus. Six inches of moisture storage capacity is considered normal for the soils of this region. Moisture deficits (Appendix B) are calculated when precipitation and soil moisture storage does not meet moisture demand (PE). Moisture surplus (Appendix B) is calculated when precipitation is in excess of moisture demand (PE) and of the amount needed for soil moisture recharge.



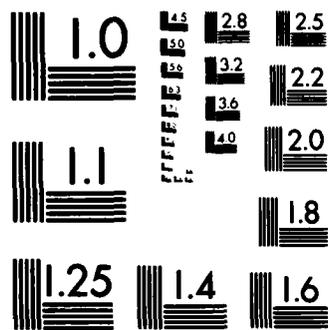
TERREBONNE PARISH-WIDE FORCED DRAINAGE
ENVIRONMENTAL IMPACT STATEMENT

REGIONALLY ADJUSTED PAN EVAPORATION DATA

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U.S. ARMY ENGINEER DISTRICT
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FIGURE IV-18



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

The climatology of the lower basin is represented by Morgan City, Thibodaux, and Houma. Precipitation maximums at these stations occur in July and September. Coastal convectional processes combined with Gulf tropical disturbances are responsible for the rainfall maximums in the late summer and early fall. The activity abruptly ends in October. Frontal movements are largely responsible for rainfall from late fall through spring. Convectional precipitation again dominates beginning in May.

The variability of the climate in the lower basin may be observed by closely examining the water balance components tables. Several periods can be identified when three-month rainfall totals exceeded 30-35 inches.

Extended wet and dry periods occurred throughout the 30-year record. The early 1950's were generally dry, followed by a slightly wet to normal period until the mid 1960's. A dry period ensued until 1973, and was followed by wet conditions through 1980.

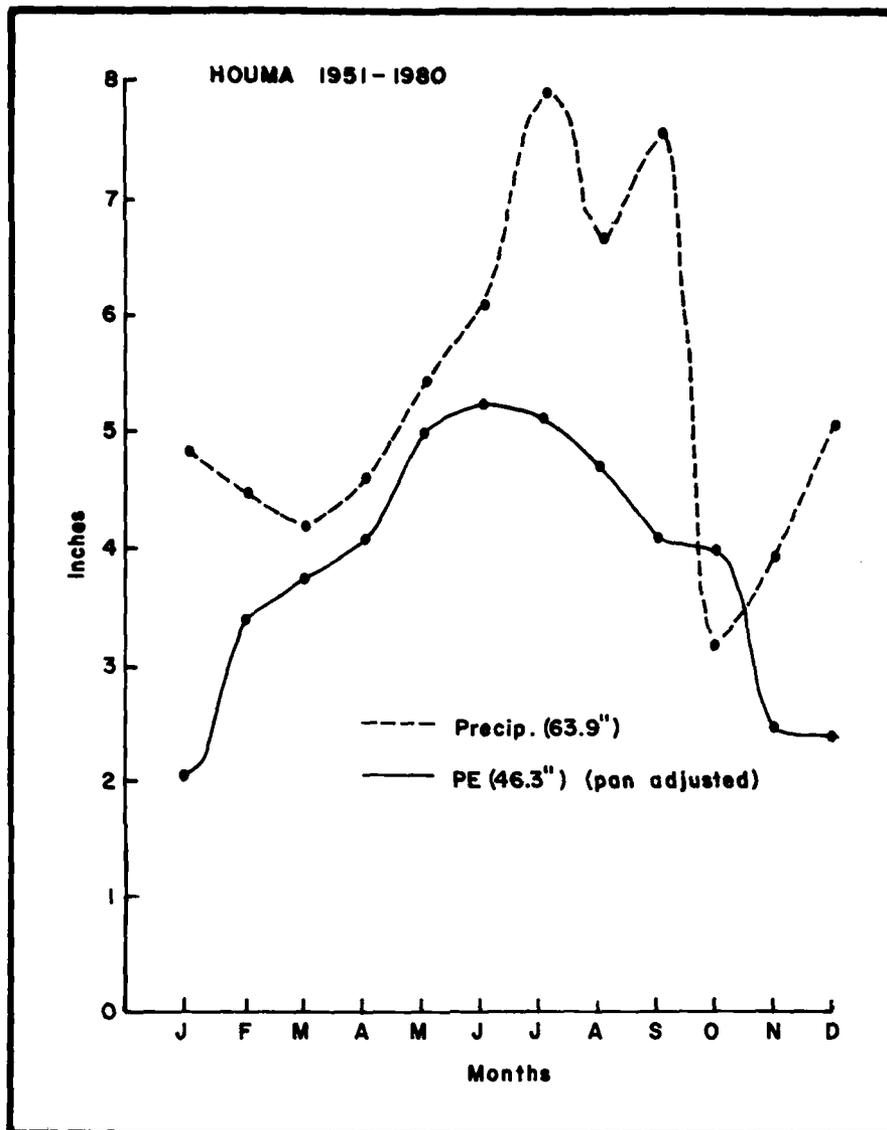
The severity of droughts and prolonged wet periods is summarized by moisture deficit (D) and surplus (S) tables. The most severe deficit occurred in 1962 and the greatest surplus was recorded in 1966. Because of Houma's coastal location, prolonged periods of drought are not as severe in terms of intensity and duration as is the case in more interior locations.

The hydroclimatology of the lower Terrebonne Basin is summarized by the average monthly patterns of precipitation (moisture income) pan adjusted PE (moisture outgo) (Fig. IV-19). Two noteworthy periods of significant rainfall excess or surplus can be observed, one in winter and another in late summer and early fall. Rainfall excesses or surpluses occur on average in all months except October, when dramatically reduced rainfall is insufficient to meet demand. Soil moisture storage is usually adequate to supplement rainfall during drier periods.

In contrast to the lower basin, the climate of the upper basin is characterized by lower but better distributed rainfall totals (Table IV-8). Baton Rouge, for example, experiences two rainfall maximums, one in April and one in July. Winter-spring precipitation totals in the upper basin exceed those in the lower basin. The relative magnitudes are reversed during the summer-fall period. The upper basin is more impacted by winter-spring frontal precipitation, while the lower basin is more affected by summer-fall convectional and tropical rainfall processes.

The climate of the upper basin is also more variable than that of the lower basin. Baton Rouge, for example, exhibits a greater variability in annual precipitation totals than do other more southerly stations, as well as more severe drought periods. The moderating effects of a more coastal location as opposed to a more continental interior location largely explain the difference.

The hydroclimatology of upper Terrebonne Basin is summarized by the average monthly patterns of precipitation (income) and pan adjusted PE (outgo) (Fig. IV-20). Unlike the lower basin, upper basin surpluses occur primarily during the winter-spring period. The July rainfall peak and resulting surplus is caused by convectional rainfall processes, which are prominent throughout all of southern Louisiana in mid-summer.



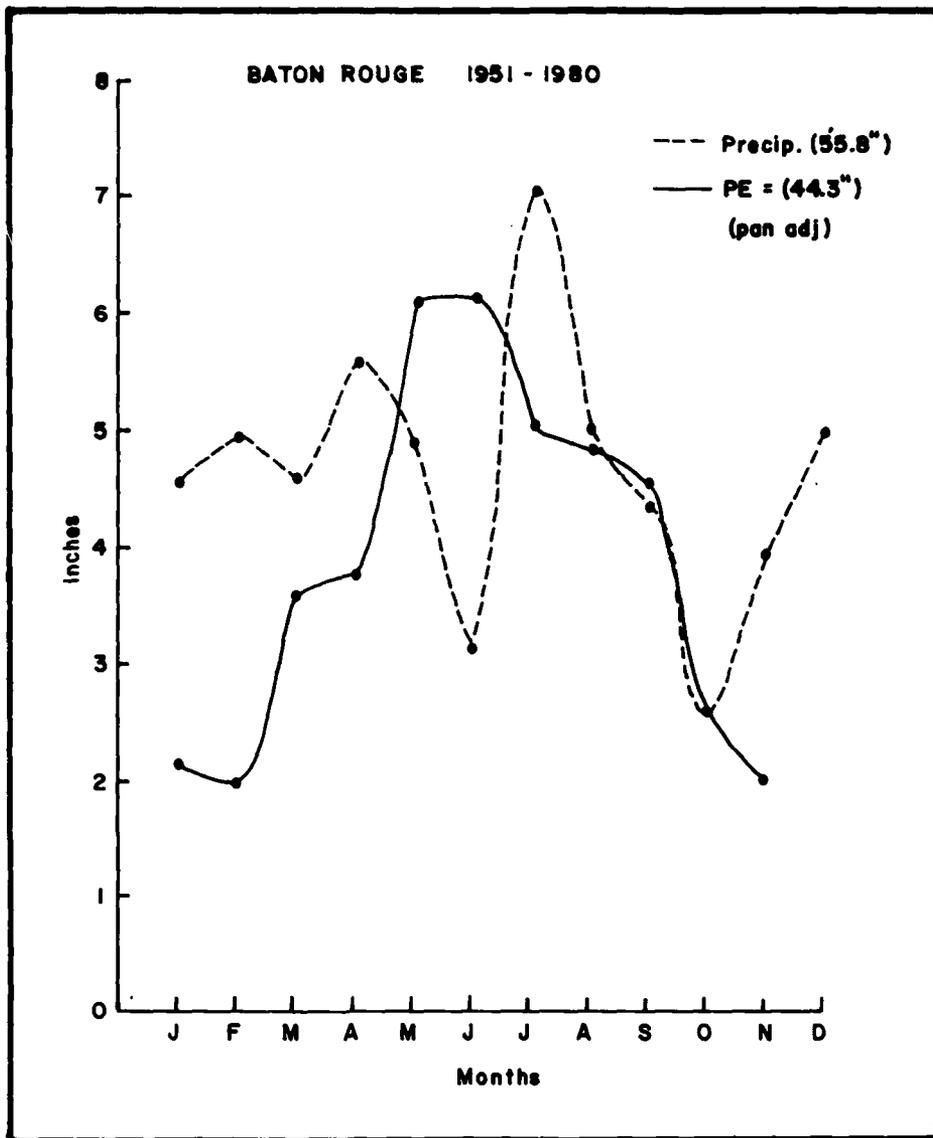
**TERREBONNE PARISH-WIDE FORCED DRAINAGE
ENVIRONMENTAL IMPACT STATEMENT**

HYDROCLIMATOLOGY OF THE LOWER TERREBONNE BASIN

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FIGURE IV-19



**TERREBONNE PARISH-WIDE FORCED DRAINAGE
ENVIRONMENTAL IMPACT STATEMENT**

HYDROCLIMATOLOGY OF THE UPPER TERREBONNE BASIN

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FIGURE IV-20

The upper Terrebonne Basin experiences significant periods of moisture deficit in the summer-fall period, whereas the lower basin does not.

Monthly runoff totals generated within the six Thiesen polygons are summarized in Appendix B. The complete monthly runoff totals are contained in Appendix B. The contrast between runoff generated in the upper and lower basins is illustrated in Appendix B. Because of differences in rainfall characteristics between the two areas, the upper basin experiences only one runoff peak in February. A second runoff peak occurs in September in the lower basin because of the precipitation maximum, which occurs in late summer and early fall. When runoff from the two areas are combined (Appendix B), the peak runoff occurs in February, with a secondary peak in September.

Monthly runoff total generated within the 12 basin sub-units are summarized in Appendix B. The runoff characteristics of the sub-basin units closely correspond to the patterns previously described for the upper and lower basins.

Since the sub-basin units surrounding Houma are generally wetlands throughout most of the year, an alternate technique for determining moisture surplus was employed. The positive values of P-PE were converted to flows (CFS) in order to better represent surplus in a wetland environment Appendix B. P-PE represents rainfall excess without considering a soil moisture recharge factor. Since it was assumed that soils were either flooded or saturated throughout most of the year, it follows that P-PE would yield a better approximation of basin surplus.

Because portions of these wetland basins sometime dry up during the late fall and winter when water levels are low, both techniques should be employed for computing basin surplus and runoff. When soils are alternately wet and dry, conventional water budget runoff calculations should be used. If soils are constantly saturated or flooded, positive P-PE is a better estimator.

Monthly summaries of P-PE and runoff for the Houma Thieson polygon are contained in Appendix B. Note particularly the large volumes of locally generated runoff, produced over several-month period in 1959, 1966, 1973 and 1975.

Water levels in the Terrebonne Basin are affected by basin-generated runoff, Gulf tidal influence, and backwater effects from the Atchafalaya River. Because of the complexity of the impacts of these processes on water levels, it is difficult to identify with certainty the singular impact of basin-generated runoff upon water levels in the basin.

Figure IV-17 identifies the locations of water level stations throughout the basin. Table IV-10 summarizes average monthly water levels for these stations. Monthly water levels (1970-1980) including variability statistics can be found in Appendix B.

The relationship between basin runoff and water levels in the upper basin is reflected in Figure IV-21. The winter runoff peak closely corresponds to low-water levels in the basin. This is caused primarily by the influence of Gulf Coast tide levels (Cocodrie), which reach their lowest annual water surface elevations in January and February. This factor dramatically reduces inflows from the upper basin to the lower basin from December through March. During this period, much of the upper basin runoff exits the systems via Bayou Chene, Bayou Penchant, and the Avoca Island Cutoff. This is particularly significant since the highest upper basin monthly runoff totals are produced during these months.

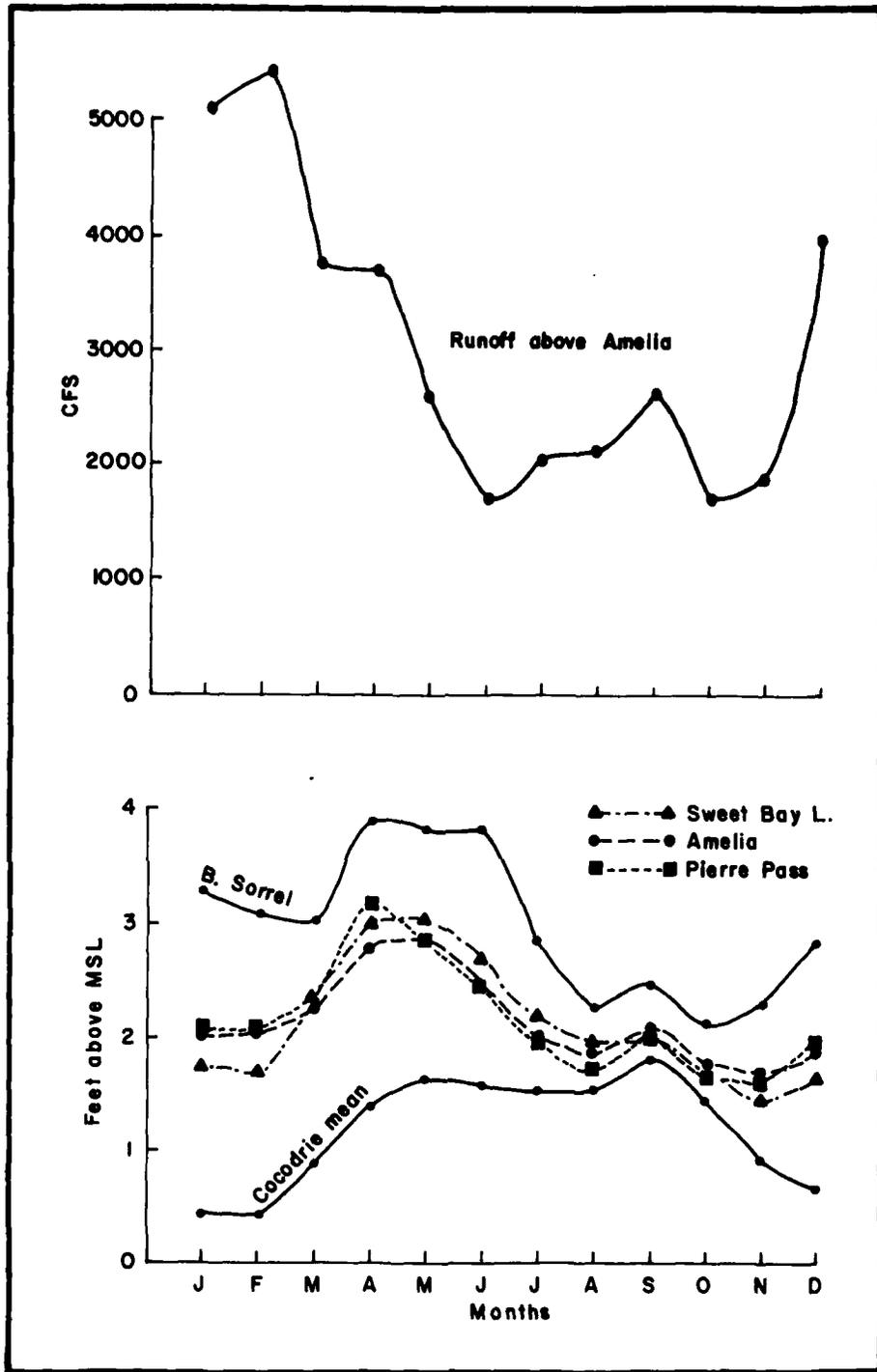
Beginning in March and continuing through June, rising Gulf tides and backwater effects of the Atchafalaya River begin to intensify the impacts of upper basin runoff upon the lower basin. Since water levels are higher in the Atchafalaya River during this period, the relief outlets for the upper basin are eliminated. Atchafalaya back water flows, especially during flood periods, combine with upper basin runoff to impact Terrebonne Parish via Bayou Black and the GIWW. Water levels at Houma, for example, averaged 1.5 feet above normal in April of 1973 because of these impacts.

Atchafalaya water levels remain higher than surrounding coastal environments until August, when water levels along the coast become strongly influenced by the highest Gulf tidal elevations of the year. This effect reaches an annual peak in September. Water levels begin to fall significantly in November because of the lowering of Gulf tides in response to the influence of frontal passages and the associated northerly off-shore wind component.

As a result of this complex set of processes, upper basin impacts upon the lower basin are somewhat minimized when considered over an annual basis. Impacts can, however, be pronounced when heavy upper basin rainfall combines with Atchafalaya back water effects and high Gulf tides. This phenomenon usually occurs at least once a year in the spring with the passage of a gulf extra tropical cyclone south of Houma. Gulf tides are frequently one to three feet above normal during these events. Water levels at Houma, for example, rose to near four feet in April 1980 in response to the passage of one of these weather systems.

Because of the primary influence of Gulf tides on water levels in the vicinity of Houma, locally generated runoff has little effect on average monthly water levels. An examination of water level data for Houma (GIWW) did reveal some periods that indicated a combined impact of basin runoff, Atchafalaya back water, and tidal effects. March and April of 1973 and May through June of 1975 are examples. One of the highest three-month totals of rainfall (over 35 inches) was recorded at Houma during 1975. The previously mentioned storm of April 1980, with associated high tides, also produced heavy rains that contributed to the water level rise at Houma. These impacts generally do not raise water levels more than one foot above normal over a 30-day period, although short-term events, lasting one or two days, can be more severe, with impacts of one to three feet.

Figure IV-22 summarizes average monthly water levels in the vicinity of Houma. The long-term effects of Gulf tides on water levels is particularly evident. The high water levels experienced in the spring and fall are generally the result of the Gulf tidal influence and the

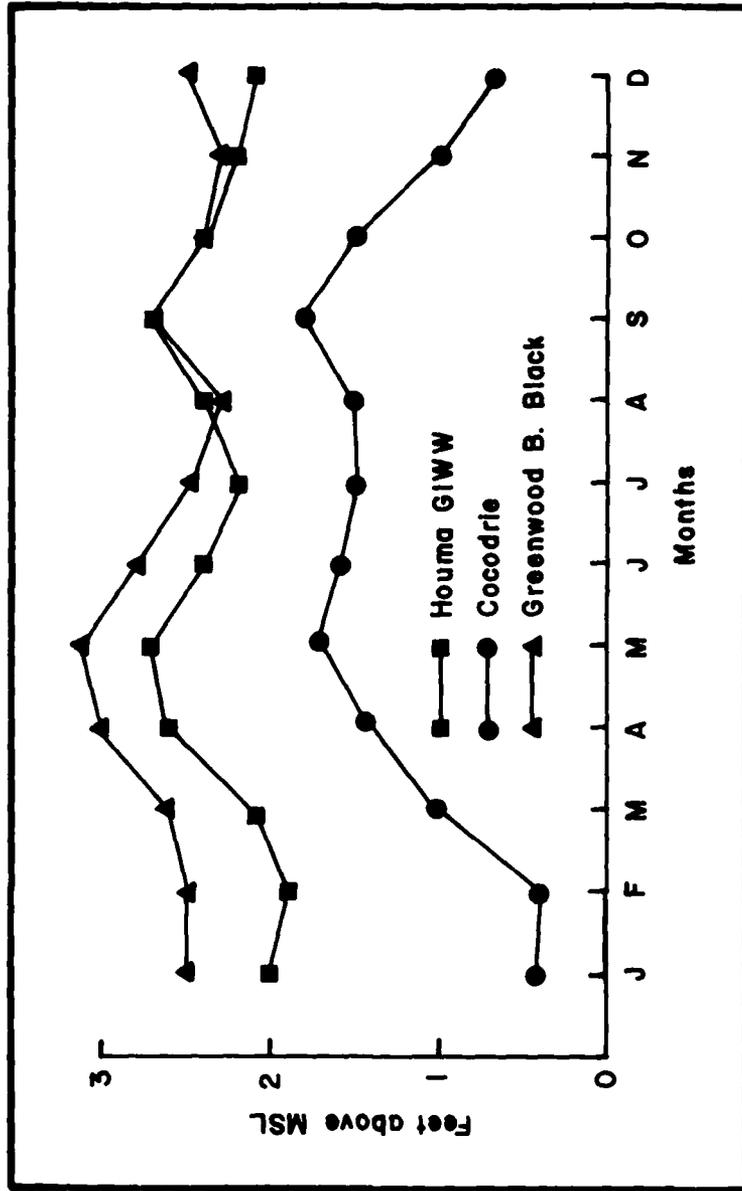


TERREBONNE PARISH-WIDE FORCED DRAINAGE
 ENVIRONMENTAL IMPACT STATEMENT

TERREBONNE BASIN WATER LEVELS

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FIGURE IV-21



TERREBONNE PARISH - WIDE FORCED DRAINAGE
 ENVIRONMENTAL IMPACT STATEMENT
 AVERAGE MONTHLY WATER LEVELS
 IN VICINITY OF HOUMA
 T. BAUER SMITH & SON, INC. U.S. ARMY ENGINEER DISTRICT
 CIVIL & CONSULTING ENGINEERS, LAND SURVEYORS & NEW ORLEANS
 ENVIRONMENTAL RESEARCH CORPS OF ENGINEERS
 HOUMA, LOUISIANA NEW ORLEANS, LOUISIANA
 FIGURE IV-22

lowering of water levels in winter. Basin runoff and back water flooding impacts are superimposed, on a short-term basis, upon the tidal regime. Water levels in Bayou Black are higher in all months except August-October.

4.1.1.5.6 Hydrologic Hazard Index. Because of the near sea level elevations of the sub-basin units surrounding Houma, the flood protection for these areas must take into account the three previously mentioned processes that impact water levels in the region. The Gulf tidal influence is of greatest importance in the overall design of levee heights because of extreme tidal elevations associated with hurricanes and tropical storms. Upper basin runoff combined with Atchafalaya back water flows will likely constitute a hazard because of the gradual rise of water levels in the Atchafalaya River associated with channel extension and delta building. Locally generated runoff will increase in severity as urban areas expand in the sub-basin units, creating additional runoff and restrictions to drainage.

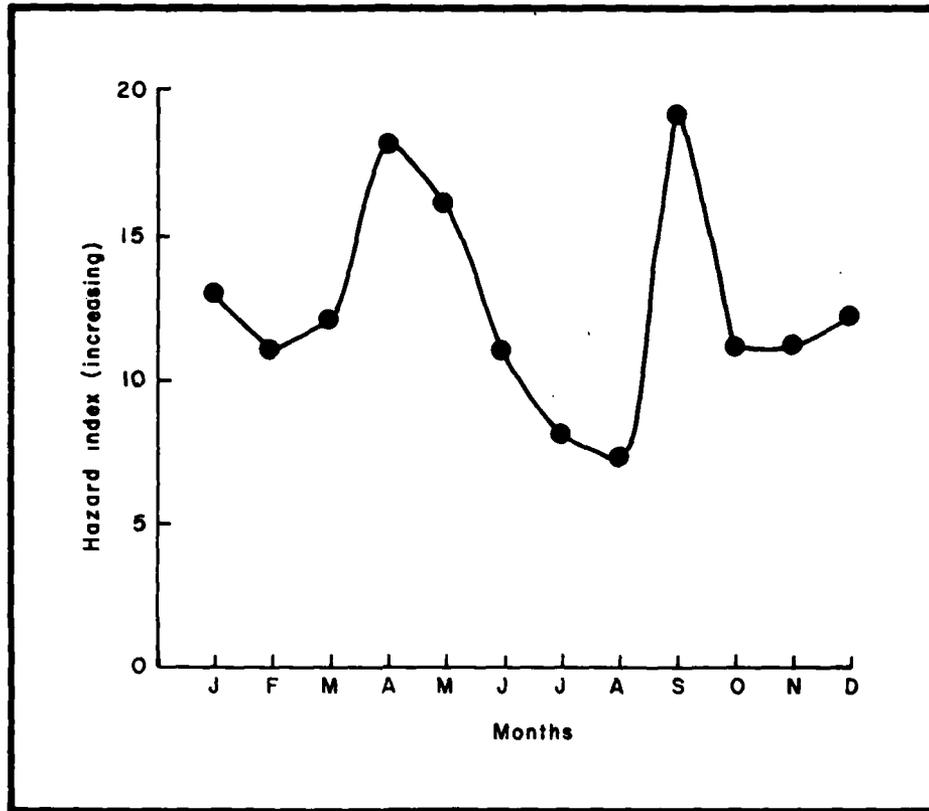
These processes, which are likely to increase in severity of impact through time, are exacerbated by the subsidence problem. This process will effectively reduce land surface elevations in urbanized environments from one inch to three feet over the next 100 years.

Annual hydrological hazards at Houma are summarized in Fig. IV-23. Average water levels at Houma were ranked 1-12 from the lowest to highest average monthly water levels. Locally generated surplus was similarly ranked on a monthly basis (1-12). The resulting scores were combined to reveal the severity of the potential monthly hazard at Houma. Water levels represent external influences upon protected drainage units in terms of levee heights and ability to drain the area. Locally generated surplus represents internal impacts within the protection units which must be drained against water levels in the surrounding wetlands. The combined monthly score reveals hydrological hazard peaks in April and September.

The spring hazard peak results from the combined effects of Gulf tides, back water flooding, upper basin runoff, and locally generated surplus. Because of the relatively high frequency and potential increase in severity of these impacts through time, the spring period may ultimately prove to be the greatest annual hazard. Had the Gulf storm of April 1980 been associated with Atchafalaya back water flooding and extreme upper basin runoff, the resulting water level rise could have been much greater.

The processes creating the fall hazard peak are less complex, less frequent, and not likely to be as significantly increased through time. The high Gulf water levels experienced in the fall are generally less variable than those experienced in the spring. The greatest danger in the fall is associated with low frequency, but often severe, tropical storms and hurricanes.

Rainfall associated with the fall hazard peak is generally not aggravated by upper basin runoff and Atchafalaya back water effects.



TERREBONNE PARISH-WIDE FORCED DRAINAGE ENVIRONMENTAL IMPACT STATEMENT	
ANNUAL HYDROLOGIC HAZARDS AT HOUMA	
T. BAKER SMITH & SON, INC. CIVIL & CONSULTING ENGINEERS, LAND SURVEYORS & ENVIRONMENTAL RESEARCH HOUMA, LOUISIANA	U.S. ARMY ENGINEER DISTRICT NEW ORLEANS CORPS OF ENGINEERS NEW ORLEANS, LOUISIANA
FIGURE IV-23	

The greatest potential for extreme local runoff results from degrading tropical storms, which sometime stall over the coastline, resulting in unprecedented rainfall totals. The North American rainfall record was established at Alvin, Texas (43 inches in 24 hours) in 1978 as a result of a degrading tropical storm.

4.1.1.5.7 Potential Effects of Forced Drainage Projects. Presently there are insufficient data available to draw irrefutable conclusions regarding possible impacts. There is, however, enough information available to indicate in a gross manner whether the building of a levee or the associated canal dredging, for example, may or may not be harmful to a particular habitat.

The habitat maps (Appendix A) provide a visual picture of the spatial relationships among the various habitat types and possible impacts by the drainage projects.

In general, levee construction along upland-wetland contacts should have minimal adverse impact on the existing hydrological regime. The raising and extension of levee systems will make more surface area available for development. If locally generated water surpluses now create either flooding or reservoir siltation problems, an increase in the developed habitat will certainly exacerbate the problems. Also the construction of new levees or the redirection of existing ones can lead to changes in circulation patterns. Of the 26 proposed projects and five unauthorized projects, 23 may be classified, at least in part, as upland-wetland contact projects.

Conversion of wetlands to other uses brings about two major hydrological changes. First, the total area of existing wetland is reduced by the area of the project. This reduction in area reduces the area potentially available for water storage; subsequent development may result in increased runoff. Second, dredging of fill material for levee construction often results in channelization of the marsh surface or improved flow conditions in existing waterways. Both actions can promote salinity intrusion.

The third type of project proposed or completed entails the construction and operation of water control structures between natural upland boundaries. When these structures are used to isolate wetland habitats the wetlands will have to be intensively managed or else they may be irretrievably lost. Of perhaps greater importance are the changes which this form of damming has on the overall drainage pattern of the area. It is suggested that these effects be considered during Phase II planning.

4.1.1.6 Water Quality. Water quality data for three major bayous and the Houma Navigation Canal are presented in Table IV-11. Also, results of water and sediment analyses from samples taken throughout the project area (Fig. IV-24) are presented in Appendix C (all appendices were published only in the Draft EIS and may be secured from the New Orleans District). As can be seen from this data, contraventions of the state's water quality standards and exceedence of EPA's water quality criteria occur frequently. The Louisiana Department of Natural Resources (1980) reported numerous contraventions of dissolved oxygen, chlorides, sulfates, temperature, pH, and fecal coliforms in and near Bayou Black from 1973 to 1978. Slightly fewer violations were reported for the drainage basin segment containing Bayous Grand Caillou and Terrebonne and the Houma Navigation Canal. Despite these apparent problems, the entire Terrebonne Basin with the exception of the estuarine areas south of Lake Boudreaux is

TABLE IV-II WATER QUALITY DATA AT FOUR STATIONS WITHIN THE STUDY AREA

PARAMETER	UPPER CATION AT DUNE				BAYOU BLAKE AT GIBSON				BALOU TERREBOINE - U.S. HWY. 90				HOUMA MARINA, SW CANAL			
	MAX	MIN	MEAN	CRITERIA	MAX	MIN	MEAN	CRITERIA	MAX	MIN	MEAN	CRITERIA	MAX	MIN	MEAN	CRITERIA
TEMPERATURE	22.08	32.00	20.18	32	20.18	30.00	20.18	32	20.18	30.00	20.18	32	20.18	30.00	20.18	32
TURBIDITY	28.18	90.00	19.71	120	19.71	120	19.71	120	19.71	120	19.71	120	19.71	120	19.71	120
CHEMICAL OXYGEN DEMAND	5.13	12.10	3.44	5.0	3.44	9.30	2.93	5.0	2.93	7.80	0.10	5.0	10.50	3.70	4.0	4.0
PH	129.38	820.40	81.73	6.0-8.5	81.73	101.90	50.76	6.0-8.5	50.76	82.90	14.00	6.0-8.5	843.91	38.40	137.12	643.91
TOTAL ALKALINITY (as CaCO ₃)	7.47	8.10	6.78	6.0-8.5	6.78	7.80	7.18	6.0-8.5	7.18	7.80	8.00	6.0-8.5	8.30	7.30	7.78	8.30
TOTAL RESIDUE	318.75	119.00	88.95	33.800	88.95	68.00	112.66	33.800	112.66	188.00	67.00	33.800	148.00	6.20	94.14	148.00
TOTAL AMMONIUM NITROGEN	1.81	3.90	1.07	0.40	1.07	1.85	1.73	0.40	1.73	3.80	0.95	0.40	3.34	0.31	1.28	3.34
NITROGEN (NO ₂ + NO ₃ as N)	0.24	0.93	0.18	0.05	0.18	1.14	0.17	0.05	0.17	0.68	0.01	0.05	0.92	0.01	0.16	0.92
TOTAL PHOSPHORUS (as P)	0.24	1.21	0.18	0.05	0.18	0.39	0.34	0.05	0.34	0.92	0.17	0.05	0.36	0.09	0.16	0.36
TOTAL ORGANIC CARBON CHLORIDES	9.52	25.00	10.00	17.00	10.00	21.00	10.37	17.00	10.37	20.00	3.00	17.00	22.00	0.50	7.40	22.00
SULFATE (as SO ₄)	1849.7	7700.00	48.51	15.90	48.51	65.00	382.18	15.90	382.18	77.40	13.90	15.90	180.00	88.10	5390.91	180.00
TOTAL ARSENIC	265.57	2250.00	17.70	4.00	17.70	45.00	87.10	4.00	87.10	57.10	7.00	4.00	1375.00	0.00	588.63	1375.00
TOTAL CADMIUM	14.16	52.90	6.10	1.00	6.10	14.40	10.84	1.00	10.84	29.90	8.10	1.00	78.90	1.70	12.83	78.90
TOTAL CHROMIUM	1.80	8.30	0.83	0.40	0.83	1.20	1.48	0.40	1.48	6.8	0.40	0.40	8.40	1.0	3.90	8.40
TOTAL COPPER	11.40	86.00	4.3	1.00	4.3	17.0	4.08	1.00	4.08	13.90	0.60	1.00	83.10	1.90	10.36	83.10
TOTAL LEAD	77.84	298.00	139.23	6.00	139.23	630.80	126.33	6.00	126.33	720.00	4.70	6.00	38.83	3.80	38.83	38.83
TOTAL MERCURY	11.97	82.40	10.37	35.00	10.37	35.00	14.08	35.00	14.08	68.90	6.60	35.00	440.00	0.90	22.11	440.00
FECAL COLIFORM	0.10	0.20	0.05	2	0.05	0.10	0.08	2	0.08	0.10	0.00	2	0.10	0.10	0.33	0.10
	1384.68	7000.00	318.75	3300.00	318.75	3300.00	16668.00	3300.00	16668.00	24000.00	230.00	3300.00	1100.00	20.00	136.43	1100.00

0. CRITERIA FOR HEAVY METALS FROM EPA. RUNNING WATER STANDARDS.
 OTHER CRITERIA FROM 1977 LOUISIANA STREAM CONTROL COMMISSION
 WATER QUALITY CRITERIA
 FECAL COLIFORM - FOR THE SEGMENT TO BE USED FOR PRIMARY CONTACT RECREATION
 10% OF TOTAL SAMPLES DURING ANY 30 DAY PERIOD SHOULD NOT EXCEED 400/100 ml
 *4. FOR THE PROPORTION OF SHELLFISH, 10% OF TOTAL SAMPLES ORDINARILY SHOULD NOT EXCEED 45/100 ml

designated as effluent limited by the Louisiana Department of Natural Resources (1980). This classification means that the water quality within a given segment or basin generally meets the water quality standards and is expected to continue to do so or is expected to do so after application of the effluent limitations required by Sections 301(b)(1)(A) and 301(b)(1)(B) of the Federal Water Pollution Control Act as amended in 1972. The estuarine area south of Lake Boudreaux, which encompasses a portion of Bayous Grand Caillou and Petit Caillou, is considered to be water quality limited, which means that the waters within the basin are not expected to meet the quality standards even after limitations are placed on effluents.

Very little data exists for some of the other minor stream segments. Extensive sampling was performed throughout the basin in 1977 for a wide array of parameters including heavy metals, phenols, and pesticides; however, reporting this limited amount of data (i.e., inadequate number of samples per parameter per station) would only be misleading, especially since the data is presently four years old. It should be noted, however, that pesticide concentrations ranging from 0.005 to 2.2 micrograms per liter (ug/l) were reported at several stations and were in the greatest concentrations in the southern portions of the basin. The herbicides, 2-4D and 2-45T, were the most prevalent pesticides as was the insecticide DDT and its derivatives (i.e., DDD and DDE).

The major water quality problems throughout the basin are low dissolved oxygen (DO) and high coliform levels. Most of these violations or problems can be attributed to inadequate municipal wastewater treatment systems, particularly those in Houma and Morgan City. Excessive concentrations of fecal coliforms and other bacteria create an increase in the biological oxygen demand and thus aggravate the already low DO problems. Upgrading of the treatment facilities in many municipalities is planned to begin within the next few years or is presently ongoing. However, increasing populations in these major cities pose additional problems.

Other probable sources which have been cited include the numerous seafood processing plants which have no or inadequate treatment facilities. Many such facilities are concentrated in the southern portions of the basin, near Bayous Grand Caillou and Petit Caillou, which could be a major contributor to this area's classification as water quality limited, as discussed previously. Marine traffic, docking facilities, and activities associated with commercial fishing are also potential sources of coliforms. Oils, greases and other contaminants also contribute to the pollutant problem. Other industrial facilities apparently are adequately treating their effluents and are expected to further decrease their loadings by the year 2000. Excessive bacteria levels are a major reason for closing waterbodies to shellfish harvesting. Extensive areas in the southern portion of the basin have been closed since 1973 for this reason. Geldrich (1969) showed a correlation between fecal coliform and the presence of the pathogen Salmonella in nonsaline waters. At concentrations ranging from 201 to 2,000 fecal coliform colonies per 100 milliliters, Salmonella is expected to occur approximately 85 percent of the time; and at concentrations greater than 2,000 colonies per 100 milliliters, the percentage of occurrence of Salmonella would be approximately 95. As shown on Table IV-26 fecal coliform levels frequently exceed 2,000 throughout the basin. These pathogens, as well as other toxic substances such as mercury, lead, and DDT, are readily accumulated in certain tissues of fish and shellfish. Additionally, the heavy metals and chlorinated hydrocarbons can be biomagnified through the food web.

Saltwater intrusion is another major factor in the degradation of the area's water quality. Excessive concentrations of chlorides and total dissolved solids, as well as reduced oxygen levels, have been attributed to this phenomenon. Increased suspended solids can have detrimental effects upon the aquatic ecosystem by allowing toxic substances such as lead and chlorinated hydrocarbons to remain in suspension throughout the water column for longer duration. Pelagic species such as shrimp and menhaden can avoid these problem areas; however, sessile organisms, such as oysters, may be killed if the condition remains for an extended period of time. Additionally, suspended particles create potential problems by clogging the gills of filter feeders, reducing vision of predator species, affecting the buoyancy of eggs, decreasing light penetration and consequently photosynthesis, clogging gills of fish, and possibly smothering benthic organisms.

4.1.1.7 Air Quality. The Department of Natural Resources, Office of Environmental Affairs, Air Quality Division performs continuous and non-continuous air quality monitoring (Figure IV-25 and Table IV-12). Continuous ambient air quality data are gathered for ozone and non-continuous data are gathered for total suspended particulates and nitrogen dioxide.

Ozone, a specific type of oxidant, is a colorless gas produced when reactive organic substances and nitrogen oxides accumulate in the atmosphere and are exposed to the ultraviolet component of sunlight. Ozone can also be formed naturally in the atmosphere by lightning and in the upper atmosphere by solar radiation. In common terms, ozone is pungent, colorless, toxic gas that contributes to photochemical smog.

For the year 1980, Louisiana had a total of five ozone monitoring sites as follows:

1. Baton Rouge
2. Carville
3. Garyville
4. Lake Charles
5. New Orleans

Various types of ozone data from the above five monitoring sites are presented in Tables 1 through 8 in Appendix D (all appendices were published only in the Draft EIS and may be secured from the New Orleans District). Also, Table 9 in Appendix D contains ambient air quality standards for continuous data.

Total suspended particulate (TSP) consists of infinely divided particulates that remain in the air for extended periods.

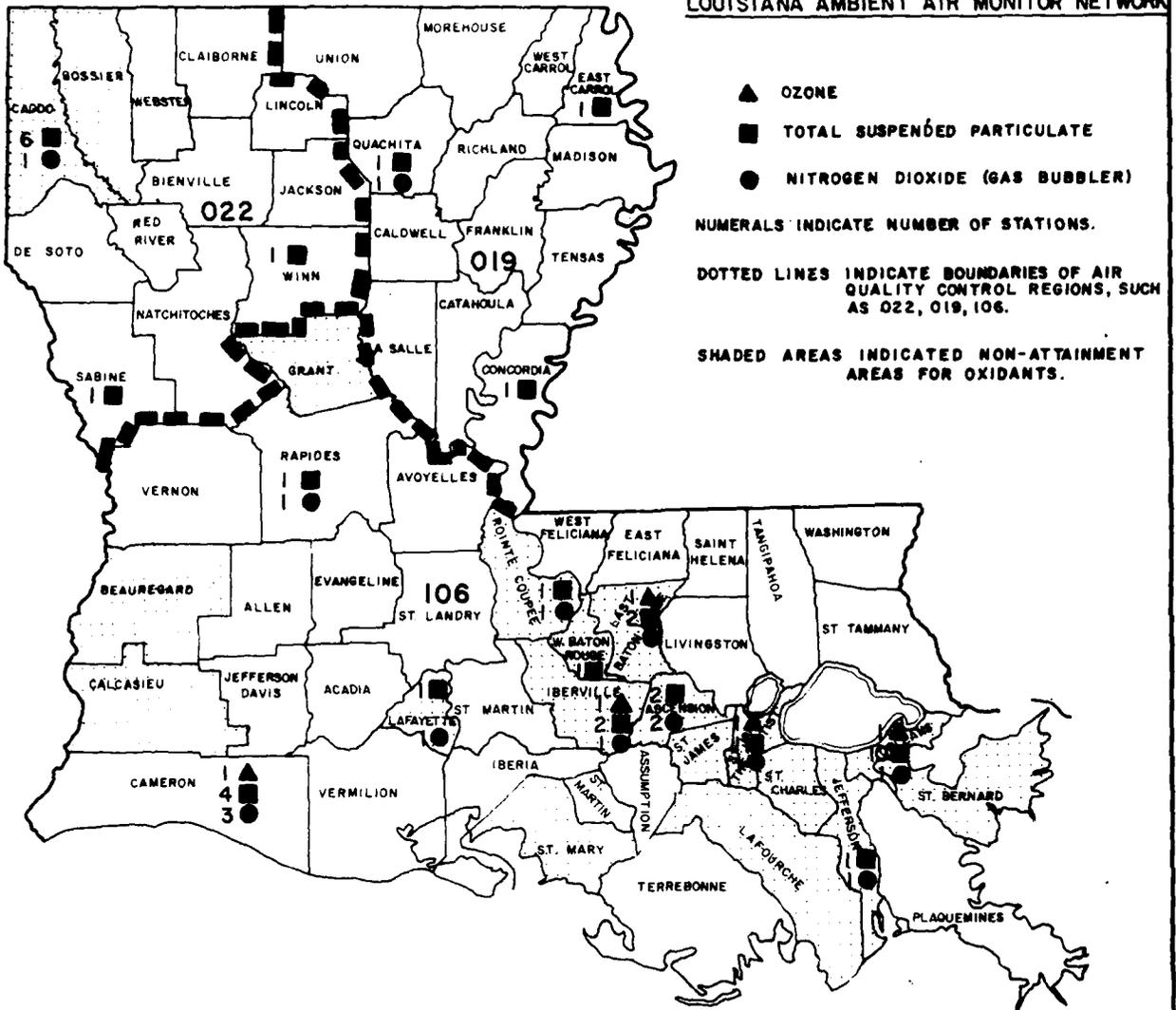
Total suspended particulate (TSP) data are presented in Tables 10 through 14 in Appendix D.

Nitrogen dioxide is a gas resulting from the operation of the internal combustion engine, fuel combustion and other sources. It is important as an air pollutant because of its role in "smog" formation. It is a reddish-orange-brown gas with a characteristic pungent odor. It is primarily produced in air-fed combustion processes where temperatures exceed 2000°F.

Nitrogen dioxide data are presented in Tables 15 through 16 in Appendix D. Table 17 in Appendix D contains ambient air quality standards for non-continuous data.

1980

LOUISIANA AMBIENT AIR MONITOR NETWORK



**TERREBONNE PARISH-WIDE FORCED DRAINAGE
ENVIRONMENTAL IMPACT STATEMENT**

LOUISIANA AMBIENT AIR MONITOR NETWORK

T. BAKER SMITH & SON, INC.
CIVIL & CONSULTING ENGINEERS,
LAND SURVEYORS &
ENVIRONMENTAL RESEARCH
HOUMA, LOUISIANA

U.S. ARMY ENGINEER DISTRICT
NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

FIGURE IV-25

TABLE IV-12. Continuous and Non-Continuous Air Monitoring Stations

	TOTAL # OF SITES	# OF SITES REPORTED TO NADB	# OF SPECIAL AIR MONITORING SITES
<u>CONTINUOUS MONITOR</u>			
Ozone	5	5	-
<u>NON-CONTINUOUS MONITOR</u>			
Total Suspended Particulate	38	34	4
Nitrogen Dioxide	19	15	4
Total number of active sites:		42	
Total number of sites reported to NADB:		35	
Total number of special air monitoring sites:		7	

There are no air quality monitoring stations within Terrebonne Parish, resulting in a lack of site specific data. The data included in Appendix D and especially from those stations nearest the project area cannot be considered typical for Terrebonne Parish. These stations are located in or adjacent to highly industrialized areas, resulting in increased pollutant emissions.

Terrebonne Parish's existing air quality can be considered good and it is not anticipated that the proposed forced drainage program will adversely impact future air quality below present standards.

4.1.2 Biological

4.1.2.1 Flora. Vegetation characteristics are by component of the habitats. Indeed, habitats are delineated based on differences in spectral response that vegetation heterogeneity provides. Thus habitats are largely synonymous with vegetational communities. Species lists by habitat type and their importance as wildlife food are provided in Appendix E (all appendices were published only in the Draft EIS and may be secured from the New Orleans District). The functional importance of various species of flora are discussed in sections referenced in Section 4.1.2.3.

4.1.2.2 Fauna. Fauna assemblages associated with the major habitats as well as a listing of endangered species are included in Appendix F. Functional relationships among fauna are discussed in sections referenced in Section 4.1.2.3.

4.1.2.3 Ecology. Detailed ecological discussions are included for each specific habitat (Sections 4.2.2.3, 4.3.2.3, 4.4.2.3, 4.5.2.3, 4.6.2.3, 4.7.2.3, 4.8.2.3 and 4.9.2.3). Although mosquito populations are naturally high, they are not of such a dimension as to require public control programs.

4.1.2.4 Areas of Special Concern. A large percentage of the area Terrebonne Parish encompasses is comprised of highly productive habitats. Wetlands occupy most of the area of the parish and they are being lost to open water environments at a high rate as is most of coastal Louisiana (see Section 4.1.1.3). The conservation of wetlands is not only important biologically, but it also threatens the very existence of the parish.

Within the total wetland area several type-areas can be tentatively identified as areas of special concern due to one or more of the following criteria:

1. Scarcity of the habitat
2. Functional importance
3. Value to economically important species

The barrier islands of Terrebonne Parish (see Section 4.1.1.3) serve as a control gate for salt water intrusion, absorb storm-wave energy, and provide nesting habitat for shore and sea birds, and have historically provided nesting habitat for sea turtles.

Flotant marshes are freshwater marshes which are dominated by Panicum hemitomon in the climax stage. Northwestern Terrebonne Parish contains the largest contiguous area of flotant marsh in the state. This area typically produces high fur and alligator harvests. Flotant is

particularly susceptible to saltwater intrusion, as there are no salt tolerant species that will survive as floatant. The transformation from marsh to open water is therefore very rapid.

Dry bottomland hardwood forests have virtually disappeared from the area since they occupied the higher natural levees and were therefore the first habitat to be directly impacted by man. Wet bottomland hardwood forests have also been depleted to a large extent. Their present distribution is largely confined to transition zones bordered by cypress-tupelogum swamps or marshes at a lower elevation, and by agricultural fields or urban areas at a higher elevation.

Relatively large expanses of second growth cypress-tupelo swamps exist in the northern part of the parish, extending across the political boundary. The size of these areas combined with non-logged (usually storm damaged) virgin cypress provides important habitat for bald eagles, especially along the marsh-swamp interface.

Remaining unsettled natural levees are few and provide important habitat for white-tailed deer and are frequently used as resting places for migratory birds after their long flight across the Gulf of Mexico.

The more saline areas of southern Terrebonne Parish support important oyster grounds and serve as shrimp nurseries.

The marshes of western Terrebonne Parish are presently somewhat unique from the rest of the state, as they are undergoing processes of restoration due to sediment and freshwater inputs from the Atchafalaya River.

Areas in west central Terrebonne Parish are consistently heavily utilized by waterfowl.

More specific locations of areas of special concern are listed under the appropriate section in the habitat discussions (Sections 4.2-4.9).

4.1.3 Social

4.1.3.1 Land Uses. In 1978 Terrebonne Parish consisted of 1,347,126 acres of land and water. Land comprised 51.8 percent and water 48.2 percent (Wicker *et al.* 1980). About 88 percent of the land is undeveloped and 12 percent developed. In the developed category over five percent is in industry, nearly four percent in agriculture, over 0.1 percent in commercial enterprises, nearly two percent residential, and about 0.2 percent designated as public lands (South Central Planning and Development Commission and Acadia Planning and Development District, 1974).

Land use patterns and practices have developed through occupation by diverse peoples ranging from prehistoric Indian times to the present. The natural levees that penetrated through rich and diverse faunal and floral communities provided the high ground for settlement. Agriculture production for the prehistoric horticulturists was likely a part time activity, accomplished in conjunction with other subsistence pursuits.

European settlers arrived in the early 18th century and settled along the bayous in the northern part of the parish. They adopted crops such as

corn and squash from the Indians, and rice, indigo and sugar cane from the West Indies. Plantation agriculture began to develop in the mid-1700's with cotton the major crop followed soon after with sugar cane and indigo (see Section 4.1.3.2.5 for additional information on historic settlement patterns).

Acreage devoted to sugar cane continued to expand, and plantations became a major pattern in the parish. The past several decades have witnessed a shift from sugar cane production to other enterprises.

Commercial shrimping became important in the first quarter of the 20th century. Fisheries production activities increased along the bayous until the area became dominated by petroleum production and related activities. Increased petroleum activity resulted in construction of the Houma Navigation Canal. Houma became a hub for commercial and industrial development around petroleum-related industries. This has resulted in a decline of agricultural and commercial fishing pursuits. At the present time population increase, industrial, commercial development and transportation corridors are vying for space along the restricted natural levees.

4.1.3.2 Cultural Features. This investigation covers prehistoric and historic cultural resources in Terrebonne Parish that may be impacted by the forced drainage program. This study is limited to Phase I of a two phase approach prior to program implementation. Phase I is designed to provide a comprehensive framework for coordinating future project investigations. The study includes 31 forced drainage projects, five of which were completed prior to the time that permitting processes were required. These are referred to as unauthorized projects. Levee alignments for the proposed projects are located along the wetland/non-wetland interface where possible.

The goals of this project (Phase I) comprise a literature and archival search of previous investigations in the area concerning archeological and ethnological resources. This includes the location of previously identified or reported sites and a habitat evaluation of those that are located within or near the project areas. Considerations are given to criteria used to identify areas where there is a high probability of cultural remains. If other cultural remains are found, additional field investigations would be required. Data gaps are identified, and recommendations for a research strategy that assists in selection of individual alignments that serve as a guide for Phase II field investigations are addressed. No field investigations were included in Phase I. Since topological and geological aspects of Terrebonne Parish receive separate treatment, only those physical and biological elements that are relevant to site significance and ethnohistory will be discussed.

4.1.3.2.1 Cultural Resources Survey Report. In the archival and literature search, libraries at Louisiana State University, Nicholls State University and Tulane University provided much of the material. The library of the U.S. Army Corps of Engineers, New Orleans District, houses valuable information in environmental impact study files. Permit request reports in Louisiana's Department of Culture, Recreation and Tourism, Division of Archaeology and Historic Preservation, files were studied. Their site records and map files contained the location and description of both prehistoric and historic known sites. The study was discussed with

personnel in the Division of Archaeology and they made valuable suggestions on data sources and report procedures. The records of the National Register of Historic Places were checked for listings. Queries were made to determine sites nominated and those planned for nomination to the National Register. Pertinent information on sites and individuals involved in studies relevant to Terrebonne Parish was provided by the curator of the Museum of Anthropology in the School of Geoscience, LSU.

4.1.3.2.2 Previous Archeological Research. Nineteenth Century reporting of archeological sites in coastal Louisiana came primarily from engineers, botanists, geologists, historians and geographers. Reference to the presence of Indian mounds was secondary to their primary goals for being in the area. Foster's (1873) book on prehistoric races of the United States was an exception.

The first report of archeological sites in Terrebonne Parish was reported by an anonymous author in 1851. The author mentions that 15 to 20 mounds of various sizes were located along Bayou Black about 40 km from Houma (Neuman 1977). Peacock and Carrighan (1951) described the mounds and recovered human skeleton material from part of the group at the Gibson site (16T-R5).

By the end of the 19th century Indian mounds had been reported across the Louisiana coast by many authors. As Neuman pointed out (1977) the early references are an important part of the archeological record that has been "irrevocably lost". Noteworthy to the antiquity of Indian occupation in coastal Louisiana was the discovery of the Avery Island site in Iberia Parish (Owen 1863). Fragments of cane matting was discovered below a layer containing fossil animal bones including mastodon. The matting was removed before it could be properly documented, resulting in much controversy that remained unresolved until the mid-20th century (Gagliano 1967).

In the early part of the 20th century Collins (1927) from the Smithsonian Institute initiated professional archeological surveys and excavations in the coastal area. His surveys extended from east of the Mississippi River to the chenier plain area in the western part of the state. He noted many sites in Terrebonne Parish and observed that the parish contained more sites than other coastal parishes. Collins was assisted in Terrebonne Parish by Randolph A. Bazet, an amateur archeologist who subsequently assisted other professionals in the area. Bazet's efforts contributed significantly to the archeology of Terrebonne Parish. Collins' systematic study was the beginning of a trend that resulted in developing a chronological framework and relationship between sites in the state. Kniffen (1936) conducted field surveys in St. Bernard and Plaquemines parishes and in 1938 contributed similar studies for Iberville Parish.

There were two research projects that added to this developing chronology; first was the Lower Mississippi Valley Survey that conducted research during the 1940's and early 1950's; and second was the Louisiana State Archaeological Survey that was active between 1938 and 1941. Contributions of James A. Ford (1936 and 1951), Philip Phillips (1970 and 1951), James B. Griffin (with Phillips 1951), Ford and Quimby (1945), Ford and Webb (1956), Ford and Willev (1940), Quimby (1942) and Czajowski (1934) resulted in the chronology presently used by students in the area.

In the early 1950's McIntire (1954, 1958 and 1971) conducted a coastal survey in conjunction with studies on development of the Mississippi River deltaic and marginal chenier plain. He used the chronological framework developed during the previous two decades. Saucier (1963), Gagliano and Saucier (1963), and Gagliano (1963 and 1967) added to the knowledge of the area and continue to make significant contributions. Gagliano's study on Avery Island (1967) constitutes a landmark effort.

The last two decades have witnessed a greater sophistication of methods toward understanding the total relationship between man and the coastal habitat at the time in which he lived (Gagliano *et al.* 1979; Springer 1973; Altschul 1978) and the complex history of time and space occupancy of a dynamic and changing habitat. For a more detailed discussion of the development of an archaeological research in the coastal area, refer to Neuman (1977) and Altschul (1978).

4.1.3.2.3 Cultural Setting. This section covers the sequence of prehistoric and historic occupation of Terrebonne Parish. The parish occupation patterns constitute a small section in a much larger geographic context. The prehistory of the area is linked both up-valley to the north, and east from Florida. There appears to be minimal influence from the Texas area. Conversely, there were introductions into Texas from coastal Louisiana. It is recognized that there is a diversity of settlement patterns and groups that inhabited the area through time and space but it is poorly understood. Studies (Springer 1973; Gregory in Thomas *et al.* 1977) indicate what would be expected for the area, that widely different groups developed and persisted under the same conditions. The record of settlement in the coastal area extends over at least the last 12,000 years (Gagliano 1967). Delta processes are dynamic, and through the last several thousand years the land-wetland environments have been one of continual change.

4.1.3.2.4 Prehistoric Resources. The prehistoric chronological sequence established for the Lower Mississippi River Valley is generally accepted as a framework for relating index artifacts to adjacent areas. Prehistoric sites in coastal Louisiana range from temporary hunting and fishing camps to more permanent villages. The sites which remain as evidence of former Indian occupation are divided into five types: shell middens, earth middens, shell mounds, earth mounds, and beach deposits.

Shell middens are by far the most numerous type along the central Gulf coast. They comprise the refuse heaps of shucked shells and other kitchen wastes discarded at the dwelling sites. Rangia cuneata (brackish-water clam) makes up the widest spread and most extensive shell accumulations. This clam undoubtedly played an important role in the economy of the inhabitants. Depending on the regional location and the local environment of the site, oysters (requiring more saline water) or Unio (freshwater clam) shells dominate the site matrix. Some localities reveal stratification of shell types and are good indicators of changes in the local environment.

Earth middens are less numerous but become more important with increasing distance from the source of crustaceans for food. They are characterized by dark humus layers caused from decay of organic refuse which accumulated at lived-on sites. Mixed with the humus are found

assorted artifacts and fish, animal and bird bones.

Shell and earth mounds are hillocks intentionally formed by their builders and vary in size of more than 18 feet in height, and 150 feet in diameter. The mounds were constructed as burial or ceremonial (temple) monuments. Mound shapes are usually conical or truncated pyramids. The earthen mound is more numerous, but there are examples of shell mounds in the coastal area.

Beach deposits are wave-formed accumulations of shell intermixed with wave-worn artifacts. They are found where the Gulf, inland lakes or estuary shores have truncated former river distributaries, and reworked midden or mound materials which comprise part of the beach deposit matrix. Beach deposits are evidence of coastal erosion where former middens or mounds were located on natural levees or beaches which formerly extended beyond the regressive present shoreline.

The sequence from oldest to youngest is listed below, along with salient diagnostic characteristics:

1. Paleo-Indian. 10,000 B.C.--6000 B.C.

Diagnostic traits: Lanceolate stone projectile points with or without flutes extending up the long axis of the points. The fluting may be unifacial or bifacial.

Basis for Temporal Placement: Assignments based upon point typologies, geologic and paleontologic correlations and radiocarbon dates from the Avery Island site, Iberia Parish.

Subsistence Economy: Hunters and gatherers. Excavated sites reveal artifacts tentatively assigned to strata containing bone of extinct Pleistocene fauna.

Settlement Pattern: Archeological deposits are indicative of small, temporary campsites.

2. Archaic. 6000 B.C.--500 B.C.

Diagnostic Traits: Medium to large, triangular projectile points having variously-shaped bases with or without notched side edges, chipped stone scrapers, knives, drills, graters, microblades, ground stone beads, celts, plummets, gorgets, effigies and steatite vessels. Antler atlatl hooks, bone awls, shell ornaments and Poverty Point baked clay objects. Artifacts of exotic raw material are most commonly associated with Poverty Point components.

Basis for Temporal Placement: Projectile point typologies and radiocarbon dates.

Subsistence Economy: Hunters and gatherers. No physical evidence of horticulture.

Settlement Pattern: The enormous earthworks at the Poverty Point site, West Carroll Parish, comprised of a mound and concentric, semicircular ridges. A low, domed, earthen tumulus was tested on Avery Island; also several campsite deposits in the Lake Pontchartrain area. At the Monte Sano site, East Baton Rouge Parish, excavations revealed remains of a structure having a square floor pattern.

3. Tchefuncte. 500 B.C.--A.D. 250

Diagnostic Traits: The major introduction of pottery. Vessels are conical with multiform, tetrapodal bases. Incised, brushed, punctuated and stamped decorative motifs appear on the vessel body and rim exterior. Also introduced are decorated, tubular, clay pipes. Stone, bone and shell implements and baked clay objects are common and similar to those of the Archaic Period, but not nearly as plentiful, variable or as ornate.

Basis for Temporal Placement: Stratigraphic excavations and radiocarbon dates.

Subsistence Economy: Hunters and gatherers. Indications of horticulture from the Tchefuncte deposit at the Morton Shell Mound, Iberia Parish.

Settlement Pattern: Sites predominate in the marsh areas of southern Louisiana and are characterized by shell middens. Inland sites consist of small, low, earthen mounds and middens containing primary flexed and secondary human interments associated with sparse amounts of artifacts. Some evidence of light-poled structures having an oval floor pattern.

4. Marksville. A.D. 250--A.D. 700

Diagnostic Traits: New pottery types comprised of bowls, globular and jar-shaped vessels elaborately decorated on exterior with punctuated, incised and stamped motifs. Vessels also decorated with red pigment and stylized zoomorphic motifs. Stone and ceramic platform pipes and effigies. Artifacts of exotic raw materials including copper, quartz crystals, asphaltum and galena.

Basis for Temporal Placement: Ceramic typology, stratigraphic tests, extensive excavations and radiocarbon dates.

Subsistence Economy: Hunters and gatherers. A single instance of corn and squash purported from the Marksville site, Avoyelles Parish.

Settlement Pattern: One extensive occupation, the Marksville site, consists of a group of earthen mounds within a semicircular ridged, earthen wall. Domed mounds for the disposal of the dead. Human interments, both primary and secondary, are deposited along with a selected quantity of pottery, stone, bone, shell and copper funerary offerings. Other sites consist of middens and/or mounds lacking enclosures. Evidence of a possible house structure, rectangular in plan with a semisubterranean floor, was exposed at the Marksville site.

5. Troyville-Coles Creek. A.D. 700--A.D. 1100

Diagnostic Traits: New ceramic typologies, clay tempered pottery and new decorative designs. Elbow-shaped clay pipes, ear spools and mealing stones. Near the end of this period the preponderance of small, finely chipped projectile points is indicative of the introduction of the bow and arrow, whereas previously the atlatl predominated.

Basis for Temporal Placement: Ceramic typology, stratigraphic tests, extensive excavations and radio-carbon dates.

Subsistence Economy: The first definitely documented evidence of corn and squash agriculture. The agricultural base was supplemented with hunting and gathering.

Settlement Pattern: Characteristically, three, large, pyramidal, compound mounds oriented around an open plaza. Houses with rectangular or oval floor patterns. Mounds of the Troyville site, Catahoula Parish, were surrounded by a rectangular ditch and earthen wall enclosure. Multiple primary and secondary human interments, generally without artifactual associations, are common in the mounds.

6. Mississippian. A.D. 1100--Historic Period

Diagnostic Traits: New ceramic typologies, shell tempered pottery, effigy vessels, new decorative motifs, strap handles, effigy pipes and ear spools. Late in the period native artifacts are found in association with European trade material. "Southern Cult" items are also present.

Basis for Temporal Placement: Ceramic typology, stratigraphic tests and ethno-historic documentation. Included are sites of the Plaquemine Period.

Subsistence Economy: Corn, squash and bean agriculture supplemented by hunting and gathering.

Settlement Pattern: Large, compound, pyramidal mounds oriented around an open plaza. Mounds may have stepped ramps. Round, rectangular and square house floor patterns with and without wall trenches. Some villages surrounded by a wooden palisade. Secondary, single and multiple human burials occur in mounds, primary extended and flexed human interments are also present. .

4.1.3.2.5 Historic Resources. Historic settlement of the area began about mid-18th century. Those present were chiefly involved in subsistence occupations from settlements near New Orleans. English, French and Creole farmers lived along the bayous in areas not frequently flooded. During the colonial period the region's principal inhabitants were the Indian tribes linguistically related to the Muskogean and Chitimachans (Kniffen 1935). At the time of European contact, three tribes lived in south-central Louisiana. They included the Chitamacha, who settled between Charenton and Cocodrie; the Washa, who lived along the southern reaches of Bayou Lafourche; and the Chawasha, who inhabited the inland regions of Bayou Lafourche (Swanton 1911).

In the "Lafourche Interior" the Chawasha and Washa were the dominant Indian tribes. Unfortunately, little is known about either group's history or culture. Available data suggests that when the Louisiana colony was founded in 1869 both were living along Bayou Lafourche. They were, in fact, culturally related to the Eastern Maize area of North America. They practiced slash-and-burn agriculture and lived in semi-permanent villages. Their artifacts indicate maize was a significant crop along with beans, pumpkins and melons. Hunting, gathering and fishing were also important. The practice of mound building continued into early historic times, along with the manufacture of household utensils from regional clays (Kniffen 1975).

It is estimated that between 200-300 Washa and Chawasha occupied south-central Louisiana at the time of European contact. They were linguistically related to the Chitimachans, a division of the Tunican family (Swanton 1911; Kniffen 1935).

The Washa and Chawasha were reported to be living along Bayou Lafourche but hunted and camped from Bayou Lafourche to the Mississippi River. They frequently moved, but by 1718 the Washa had apparently settled in a "camp" 30 miles north of New Orleans where they lived near the Mississippi's south bank (Swanton 1911).

The history of the Chawasha ran almost parallel to the Washa. Before 1722 they moved across the Mississippi to the east bank. By the middle of the 18th century, the two groups had been displaced by European settlers and lost their identities through displacement and acculturation.

One other Indian group, the Houma, had an important impact on the history of the parish. When LaSalle encountered them in 1682, this Muskogean-speaking tribe lived on the east side of the Mississippi River opposite the mouth of the Red River (Swanton 1946). They remained in this encampment until about 1706, when the Tunicas, whom they had learned to trust, massacred a large number of their hosts. The survivors went first to Bayou St. John near New Orleans, and later into what is now Ascension

Parish. Here they established the Little and Great Houma Villages. They were eventually joined by remnants of the Bayougoula and Acolapissa tribes, who were also linguistically Muskhogean. Later the Houma migrated down Bayou Lafourche and eventually into Terrebonne Parish. By 1776 several small groups settled along the parish's navigable waterways. They established major communities at Houma, Bayou Pointe-aux-Chenes, and Bayou St. Jean Charles. Others moved to Dulac and Grand Caillou (Stanton 1971). Unlike most other "Lower Valley" Indians, the Houma have steadily increased in number. Remnants of their original settlement clusters are still a part of the "lower bayou country" south of Houma. Since they have no reservation, many have intermarried and thereby lost some of their Indian traits (Terrebonne Parish Development Board, 1953; Wakefield 1977).

The last migration of the Houma resulted in tribal members settling in other parishes, notably St. Mary, Jefferson, Plaquemines and St. Bernard. In the early 1930's several families settled in St. Mary Parish and established communities that continue. A few years later Houma trappers from the Pointe-Aux-Chenes area were recruited by landowners in St. Bernard Parish to assist in the control of fur-bearing animals in the marshlands. During and after World War II, many families moved out of their Terrebonne-Lafourche communities to the Westbank--a metropolitan area across the Mississippi River from New Orleans.

Through the years there have been attempts to organize the "tribe" into an effective Indian affairs organization to deal with local, state and federal problems. A number of local organizations were formed, but there was little inter-exchange between groups. In 1979 the United Houma Nation, Inc. was formed through the amalgamation of several groups, that should provide the mechanism for unified efforts on issues confronting the "tribe". The purpose of the incorporation was to further the economic development of the tribe. The Houma, as well as other Louisiana Indian groups, want to obtain economic independence and federal recognition so the tribe will be eligible for financial assistance from the government or private foundations.

Before 1765 few white (European) settlers lived in what is now Terrebonne Parish. Those who entered the area were explorers, hunters, trappers and fishermen from settlements along the Mississippi River. Travel accounts and archeological investigations reveal that these folks depended on the land for their subsistence in the same manner as the Indian population. Soon English, French, Acadian and Creole farmers followed and created scattered communities along the bayous in areas not frequently flooded. These farmers also came from the Mississippi River German and Acadian coasts. Another group of Acadians arrived later from Santo Domingo and settled in what is now northern Terrebonne Parish. After 1790, French refugees from the West Indies arrived in New Orleans and moved gradually into Terrebonne (Lytle, McMichael and Green 1960).

The earliest farmers migrated from New Orleans to settlements on Bayous Black, Petit Caillou and Terrebonne. In Colonial tradition, these peasants raised corn, rice, indigo, cotton and sugarcane. Cattle, pigs and chickens were also a part of the subsistence livelihood. The most successful commercial crops were indigo and cotton; neither are cultivated today, whereas the commercial vacherie-type operations that developed later continue to survive within the parish (Davis and Detro 1977).

After sugarcane was introduced about 1751 and Etienne De Bore's granulating process was accepted, the size of the plantations increased rapidly. By the 1860's more than 85 sugarhouses were operating within the parish; sugarcane had successfully superceded cotton to become the major crop (Lytle, McMichael and Green 1960).

In 1822, the area's 2000 inhabitants were scattered along the principal chenieres, coteauxes, hammocks, islands and natural levees. This "high ground" supplied farmer-trapper-fisher folk with the essential requirements for their economic existence and became the focal point of human occupancy. In all cases, the communities were accessible by water and were near their fishing, hunting, trapping and agricultural areas.

In Europe, in a wetlands environment reclaimed by dikes, a linear long-lot settlement pattern emerged. In Terrebonne Parish, this form follows the crest of natural levees and ridges. The unit of measure is the arpent, equivalent to 192 feet. Land grants were usually five to ten arpents (960 to 1920 feet) on the front, with a normal depth of 20 to 40 arpents (3840 to 7680 feet). Inheritance subdivisions were, and are, divided lengthwise (Davis and Detro 1977). The parish's natural levee settlements typify the complexity of linear settlement types. In a sense these communities are considered a homogenous unit, since people consider a bayou settlement, regardless of length, as a single entity with varying degrees of continuity.

The population, outside definite community settlement nodes, consider themselves rural, though there is a continuous row of houses along each side of the highways that parallel the major streams through the entire length of the parish.

A second settlement type occurs on the parish's many plantations. These nodes include the dwelling of landowners or operators, tenants and laborers, and outbuildings such as barns, implement sheds, and shops. Plantation settlements may have 10 to 30 dwellings as well as the general store and may be either linear or block communities. Today, they are relics of an earlier premechanization period (Rehder 1971).

Other relics include the parish's complex cultural heritage reflected dramatically in its "folk" and "grand" architecture. The variety of folk styles include shotgun, Creole, palmetto and quarterhouses, houseboats and plantation stores, "Grand" architecture is revealed in the raised cottages, English and Creole plantation houses, Greek Revival, Gothic Revival and Victorian structures (Detro and Davis 1978). A recent Cultural Resource Architectural Survey conducted by Paul Leslie recorded approximately 1200 structures in Terrebonne Parish over 50 years old. New homes are primarily ranch-style on slabs though copies of numerous "folk" styles also flourish.

Terrebonne Parish exhibits an atypical ethnic, cultural and settlement heterogeneity, one that can be described as a "melting pot". The mixing of races and nationalities such as American Indian, English, German, Irish, French, Creole, Acadian, Negro, Italian, Slavic, Filipino and Chinese resulted in a milieu that is absolutely unique in the United States (Evans 1963).

4.1.3.2.6 Prehistoric Sites--Terrebonne Parish. There are 110 recorded prehistoric sites in Terrebonne Parish. This total came from records that extend back into the 1930's and represents various levels of data about sites ranging from practically nothing to well documented finds. Some sites reported have never been located or visited by a professional archeologist. Many sites have been subsequently destroyed by shell dredging, agriculture practices, subdivision and industrial development, water control structures, canal and waterway construction. Sea level rise, subsidence and severance of sedimentation into the area has resulted in lowering the elevation of sites below present marsh and Gulf levels. The entire parish is subject to these processes that result in drowning of the coastal sector. Coastwise, the subsidence rate is greater than it is at the inner margin of the parish. With land inundation, salt water intrusion and wave erosion, the bayou channels are widened, resulting in site destruction and habitat alteration. An additional factor concerns the location of a site with respect to the distributary channel and natural levee crest present at the time of occupation. Developing channels widen and deepen. Closing channels silt in and narrow through time. From what is known about delta formation and deterioration, the parish has experienced more than one cycle of formation and deterioration, a condition that is occurring at present.

The oldest sites in Terrebonne Parish that have been identified contain Marksville ceramic types. This includes the Gibson site 16Tr5, the Mandalay Plantation site 16Tr1, the Waterproof site 16Tr14, and the Bergeron School site 16Lf33. The Gibson and Mandalay Plantation sites are located along Bayou Black. The Marksville component at the Gibson site (McIntire 1958) came from a Rangia shell midden along the bayou edge fronting the eastern-most earthen mound. Only the top portion of the midden extended above the surface of Bayou Black deposits. Subsurface augering clearly showed the midden material intermixed with red silty clay. This indicates that the Red River continued to flow in the channel (Howe 1931; Russell 1938 and 1940) after Teche Mississippi River abandonment; and this evidence provides an approximate time when the Red River was flowing in the Teche Mississippi channel. Paired, Red River levee deposits are conspicuous exposures along Bayou Teche upstream from Morgan City. McIntire (1958) found no evidence that the earthen mounds at the Gibson site were constructed during the Marksville period. The Waterproof site Tr73 was considered to be located on a relict distributary that flowed off the Teche Mississippi channel prior to burial by Lafourche-Bayou Black deposits. A Red River association was not determined for the Waterproof site.

Marksville Period potsherds collected (16Lf33) from spoil deposits along Bayou Blue (Altschul 1978) provides some verification for the antiquity of the bayou. Frazier (1967) considered Bayou Blue to be a relict Early Lafourche course. Subsurface borings may reveal the levee association from which the dredged artifacts were derived. Altschul (1978) indicates that the Bergeron site extends across Bayou Blue into Terrebonne Parish.

The clusters and alignment of recorded sites in the basin between Bayou du Large and Bayou Mauvais Bois and west of Bayou Mauvais Bois constitute an area where site-distributary association is not well understood. Aside from the slightly above marsh level "high ground"

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provided by the natural levees of Bayou Mauvais Bois, the tops of Rangia shell middens and shell ridges provide the base for tree growth. Several of these outliers in the marsh are located north of Lake Decade. West of Bayou Mauvais Bois, trees form linear alignments along Rangia shell ridges that extend southwest toward Four League Bay. Evidence for Indian occupation and formation of some of the ridges visited is provided by the presence of surface potsherds. The surface collections are mostly Plaquemine Period ceramics. However, in the spoil of canals and former shell dredging locations in close proximity to the ridges, Troyville period ceramic fragments are exhumed. The relatively frequent incidence of this occurrence is sufficient to show that this region supported widespread settlement of Indians prior to and overlapping inhabitation of the Lafourche delta region.

Auger tests through the flaring edges of the shell ridges reveal that the Rangia shell bottoms out between 2-4 m below the marsh surface. Individual sites in the marshlands indicate natural levee association with the sites. However, in the linear ridges west of Bayou Mauvais Bois the base material is uncertain. Both James P. Morgan (personal communication) and McIntire have independently augered these ridges and both interpretations agree that they appear to be lake-shore based. From both an archeology and geology standpoint this region warrants more attention than it has received in the past.

Altschul's study (1978) contributed significantly to initiating studies designed to recognize difference in settlement types and distribution patterns under similar environmental conditions. Because of paucity and disparity of data the study is limited to Plaquemine Period and includes 14 sites. Although not entirely conclusive, the study recognizes that there were different social patterns between two groups. The preponderance of shell middens coastwise and mound centers up the bayous appear to show diverse settlement patterns in Terrebonne Parish. More data is required to establish the social patterns associated with seasonal migrants and mound centers. Semi-permanent settlements with some dependence on horticulture were likely.

4.1.3.2.7 Assessment of Known Prehistoric Sites. Assessment of known prehistoric sites within project areas as related to proposed levee alignments and other construction activities show that there are seven known prehistoric sites located within the project areas. Four sites are located within proposed projects and three sites are located within unauthorized project areas. Table IV-13 lists the sites according to their parish numbers and highlights information pertaining to the sites.

Based on comparison of site location maps in the state files with the 1:24,000 scale project maps, the three sites located within the unauthorized projects are all located at considerable distances from proposed construction areas. Sites 16Tr3 and Tr19 are located along the north boundary of Project 8-2C (unauthorized); however, no construction activity occurred, as the north boundary utilized the already existing road on Marmande Ridge. Site Tr26 is located in the central portion of Project 3-2 (unauthorized) and is about 400 m from the nearest levee construction location.

TABLE IV-13. Known Prehistoric Sites Located Within Proposed and Unauthorized Project Areas

Parish site Number	Project Number	Site Name	Habitat	Type Site	Culture Period	General Location to Construction-sites
TR-2	1-1B	Sanders	Other Upland	Possibly destroyed		200m from proposed levee
TR-79	1-1B	Site not located -see text				
TR-63	4-6	Bayou Blue	Other Upland	No site file		700m from proposed levee
TR-38	3-1C	Bayou LaCarpe	Bottomland Hardwood	Earthen Mounds	Plaquemine	200m from proposed levee; along side pump station
TR-26	3-2 (unauthorized)	Bayou Sale #1	Shrub Wetland	Small Shell midden	Partially destroyed, submerged	400m to nearest levee
TR-3	8-2C (unauthorized)	St. Eloie	Other Upland	Shell Midden nearly destroyed	Delta Natchezan	Near north boundary road
TR-19	8-2C (unauthorized)	Bayou Dularge	Other Upland	Large Pyramidal mound with shell	Coles Creek	Near north boundary road

Site 16Tr63 is located at the eastern end of Project 4-6. The proposed eastern boundary is along an already existing Highway (316) and the nearest proposed levee construction is approximately 700 m to the west.

Both 16Tr2 and 16Tr79 are recorded as being situated on the southeastern portion of Project 1-1B. Site 16Tr2 lies along Bayou Little Coteau approximately equidistant from the proposed northeast and southern levee some 200 m away. No site file is recorded for 16Tr79 and it appears only on the 1:62,500 scale reference maps. Field inspection of the suspected site area failed to result in any evidence of prehistoric cultural remains. Altschul (1978) reports the site as destroyed in the plowed zone. Interviews with residents in the vicinity of the suspected site resulted in no local knowledge about it. The site could be either nonexistent, destroyed or located elsewhere. If the site is located north, south, or east of its recorded location it will lie outside of the project area and there is no proposed construction activity proposed along Bayou Little Coteau to the west for a distance of 3 km. Site 16Tr38 is located in Project 3-1C along the north bank of Bayou LaCarpe and is in close proximity to a proposed pump station. The site when recorded by Kniffen and McIntire in 1952 consisted of one large earthen mound approximately 5.5 m high and 18 m square at the top, and two smaller mounds approximately 0.5-1 m in height. Two collections of artifacts from the Plaquemine Period site were collected. The small mound farthest away from Bayou LaCarpe has been destroyed, but artifacts are widely distributed in the plowed field. Field inspection revealed scattered remains to the edge of the bayou at the approximate pump location. Altschul (1978) lists this site as highly significant. It is recommended that during Phase II a 1m² test pit be excavated to sterile soil in the vicinity of the pump station on the north branch of Bayou LaCarpe in order to determine whether there are cultural remains of significant value.

4.1.3.2.8 Prehistoric Sites--Habitat and Environmental Associations. Determining the location of prehistoric sites in relation to habitats and geomorphic environments provides a useful data base for assessing the probability of finding additional unknown sites and their most probable location. This facilitates the design and helps to maximize the cost effectiveness of the field research phase (Phase II) on the assessment/impact procedure.

There are 110 registered prehistoric sites in Terrebonne Parish. Four sites are located within the proposed project areas and an additional three sites are located within the unauthorized projects. The total of seven sites is not adequate to accomplish the above stated objectives, therefore all sites located in Terrebonne Parish within the 1:24,000 scale U.S.G.S. quadrangles in which projects are to be located plus all Terrebonne Parish sites located within most of the neighboring 1:24,000 scale U.S.G.S. quadrangles were included in the analysis. This provided a total representation of 96 sites covering all areas of the parish except the extreme southeast and southwest sections.

The habitats associated with the 96 sites and their geomorphic environments are included in Table IV-14. At first view there does not seem to be any relationships between habitat type and site locations. This is primarily the result of two factors. First, the comparison is being made using different time periods. That is, the habitats are those that existed in 1978. Given the ephemeral nature of Louisiana's coastal

Table IV - 14. Location and Number of Prehistoric Sites in Relation to Habitat Type and Geomorphic Environment

<u>Habitat</u>	<u>Geomorphic Environment</u>			<u>Totals</u>
	<u>Levee</u>	<u>Lake Rim or Beach</u>	<u>Unknown</u>	
Salt Marsh	12			12
Brackish Marsh	10		2	12
Intermediate Marsh	3	1		4
Fresh Marsh	5	1	2	8
Shrub Wetland	14	1	1	16
Bottomland Hardwood	18			18
Cypress Tupelogum	10			10
Other Upland	<u>16</u>	<u>—</u>	<u>—</u>	<u>16</u>
Totals	88	3	5	96

habitats in relation to centuries of time, it is very unlikely that many of the habitats have remained the same since the sites were occupied. An obvious man-related example is the clearing of bottomland hardwoods from levees for agriculture and settlement. Second, the sites are either shell middens or earthen mounds which are frequently elevated in relation to the surrounding area. This elevation difference often results in a different floral assemblage and therefore habitat type. A small cluster of trees in an otherwise homogenous expanse of marsh is perhaps the most conspicuous example on the local landscape.

There is a strong relationship between site locations and geomorphic environment, as 88 of the 96 known sites are located on levee material. The five sites of unknown geomorphic environment are probably associated with subsidence of the natural levees. The association of prehistoric sites and levees along the Louisiana coast has been well established for some time (Kniffen 1936 and 1938; McIntire 1954 and 1958). More specifically, the sites are often located on the levees of lesser distributaries rather than the major distributary or trunk stream levees. Sites located on the major distributary levees are frequently found in the present back levee area, usually juxtapositioned on an intersecting lesser distributary, crevasse or lakeshore. It need be kept in mind that the width of channels has changed since the time of Indian occupation. Where active flow has ceased, channels fill and widths narrow upstream and can be completely filled. Downstream, through subsidence and invasion of marine waters, they widen through wave and current erosion.

4.1.3.2.9 Site Probability in Proposed Project Areas. This section is concerned with the probability of encountering additional prehistoric cultural remains in the project areas and the proposed research design in Phase II. Probability as used in this section refers to a qualitative/relative probability. While it may be desirable to determine a statistical probability in order to make more objective judgements, the data do not lend themselves well to these types of analyses and it is hypothesized that the probabilities determined would be extremely low, which may lead to some misleading impressions and therefore, conclusions.

Of the known 110 sites in the parish, seven are located within the proposed and unauthorized project areas. There are a significant but relatively low number of sites within these areas when the large areal extent of the relict natural levees that the projects encompass is considered. Undoubtedly, many sites have been destroyed through settlement and agriculture practices over the last approximately 150 years. The relatively large area of the Other Upland habitat type which primarily includes urban and cleared agricultural fields indicates the large extent of man-made change that exists within the proposed project areas.

Settlement not only increases the likelihood that sites have been destroyed, but it also increases the probability that existing sites that have not been destroyed have been located and reported.

Most of the construction activity in the form of canals and associated levees, water control structures and pumps is to take place in the back levee areas. In general, these back levee areas are still within the high probability site area. In addition, the back levee areas have been disturbed to a lesser extent by modern man as evidenced by the much lower occurrence of agricultural fields and urban areas and the increased

occurrence of such habitats as bottomland hardwood forests.

In summary, the probability of finding additional unreported sites within the project areas is low, but if unreported sites exist they have a high probability of being located in proximity to construction zones.

Whether or not additional unreported sites may be affected by construction activities will be determined during Phase II. It is proposed that field investigation include surface surveys of the entire length and width of proposed construction zones. Shallow subsurface borings should be concentrated along stream banks, sloughs and other presently existing or relict water bodies that intersect or join the main levee alignment. The depths of the borings would be determined by local conditions and considerations for reaching former buried levee surfaces and sites that may be located on them.

4.1.3.2.10 Historic Sites--Terrebonne Parish. Two antebellum homes in the study area are listed on the National Register of Historic Places. These are Orange Grove and Southdown Plantation houses. It appears that neither will be affected by a construction staging area or the levee itself. Ardoyne Plantation house was listed in the National Register of Historic Places on November 1, 1982, and it appears that it will not be affected. Records in the Louisiana State Historic Preservation Office show that interest exists in designating the Houma Central Business District as an historic district and listing Ashland Plantation house on the National Register.

J. Paul Leslie, Jr. of Nicholls State University conducted a survey of historic houses in Terrebonne Parish for the Louisiana Division of Archaeology and Historic Preservation. He located, photographed and mapped at a scale of 1:24,000, 1016 structures. It is difficult to determine from these maps if any historic houses will be definitely impacted by the forced drainage projects. Table IV-15 indicates all historic structures documented in the records that lie near or within the project areas. Careful fieldwork is required prior to the initiation of each project to insure that the homes within the impact area are not adversely affected by the project.

4.1.3.2.11 National Register of Historic Places and Management Plan Plan Considerations. The cultural resource survey of the Terrebonne Parish Forced Drainage system included an archival, map and literature survey of recorded prehistoric and historic sites that would be impacted by the 31 projects (proposed and unauthorized). No field investigations were conducted. Four prehistoric sites are located within the proposed project areas and three are in the unauthorized projects (Table IV-15). There are 31 historic buildings or structures located in or near the project areas (Table IV-15).

Site significance, based on National Register criteria, was preliminary evaluated for the seven prehistoric sites. Site significance criteria included integrity of the site, distinctive characteristics, and potential yield for contribution to the prehistoric record.

Three sites (16Tr3, 19 and 38) have previously been recommended for consideration to the National Register of Historic Places (Altschul 1978). Sites 16Tr3 and 19 are located in close proximity to one another and an area determination has been suggested for the National Register.

TABLE IV-15. Terrebonne Parish Historic Resource Survey

Quadrangle Name	Project Designation	Survey Number	House Description
Amelia	6-1B		No houses surveyed, additional fieldwork required
Bayou Cocodrie	6-3		No houses surveyed, additional fieldwork required
Bourg	4-6		No endangered structures
Cocodrie	5-4		No houses surveyed, additional fieldwork required
Dulac	8-2B	0942	No endangered structures
	8-2E		No endangered structures
	3-1CEXT		No endangered structures
	3-1A		Creole-styled; tin-gabled cottage; constructed ca. 1926 - Needs to be field-checked since it may be just outside of the boundary
		Morning Star Church	
	3-1BEXT		Needs to be field checked No endangered structures
Gibson	6-1CEXT		No endangered structures
	6-1B		No endangered structures
	6-2B	0789	Shotgun, tin-gabled, constructed ca. 1880
		0793	Shotgun, board and batten; tin-gabled, constructed ca. 1900
		0794	Shotgun, board and batten, cypress shingle roof, constructed ca. 1910
		0795	St. Lawrence Catholic Church, constructed ca. 1911.
	2-1B		No endangered structures
Gray	2-1A	0715	Magnolia Plantation, constructed ca. 18??.
	1-1B	0590	Cottage; hip-gabled roof, constructed ca. 1920
	1-1A	0626	Clapboarding, brick pillars, asbestos gable, constructed ca. 1925
		0629	Bungalow, tin-gabled roof, constructed ca. 1925
		0714	Creole T with beveled front side, tin-gabled roof, constructed ca. 1908

TABLE IV-15 (continued)

Quadrangle Name	Project Designation	Survey Number	House Description	
Houma	1-1B	0950	T-shaped structure, constructed ca. 1909	
	1-1B		No endangered structures	
	4-6		No endangered structures	
	8-2A		No endangered structures	
	8-2B		No endangered structures	
Humphreys	1-1A	0799	No endangered structures	
	6-4		No endangered structures	
	2-1B		Creole, tin-gabled roof, constructed ca. 1920	
			0800	Creole quarters, tin-gabled roof, constructed ca. 1920
			0801	Double Creole Cottage, tin-gabled roof, constructed ca. 1910
			0802	Creole Cottage, tin-gabled roof, constructed ca. 1920
	6-5		0883	Shotgun, tin-roof, clapboard, constructed ca. 1925
	6-6	No endangered structures		
	8-2	No endangered structures		
Lake Bully Camp	4-3B	1016	Rectangular stucco structure, Hebert's Store, constructed ca. 1938	
	4-3C		No endangered structures	
Lake Theriot	8-2A	0920	No endangered structures	
	8-2E		Bungalow, tin-gabled roof, constructed ca. 1930	
			0921	Creole, asbestos-slate roof, constructed ca. 1930
Lake Quitman	3-3		No endangered structures	
	5-3		No endangered structures	
Montegut	4-2B		No endangered structures	
	4-4		No endangered structures	
	4-5		No endangered structures	
Savoie	1-1B		No endangered structures	
Thibodaux	1-1B		No endangered structures	

Source: Leslie, J. P., Jr.

1980 Cultural resource architectural survey of Terrebonne Parish, Louisiana. Unpublished manuscript, Louisiana Division of Archeology and Historic Preservation, Baton Rouge, Louisiana.

TABLE IV-15.(continued)

Unauthorized Projects

Quadrangle Name	Project Designation	Survey Number	House Description
Bourg	4-1	1015	Ellender Home, Creole Cottage 1980
Lake Theriot	8-1	0922	Verret House, Creole 1900
		0923	Marmande House, Shotgun 1920
		0921	Voisin House, Creole 1930
		0920	Voisin House, 1930
Lake Theriot	8-2D	0900	Frederick House, Cottage Creole 1900
		1901	Marmande House, Eli Plantation 1925
		1902	Shotgun, 1920
		1903	Shotgun, 1920
		1904	Shotgun, 1920
		1905	Shotgun, 1925
Lake Quitman	3-2	none	none
Lake Theriot Dulac	8-2C	none	none

However, the time and occupation and social connections between the two sites are unknown. Site 16Tr19 is described as a shell midden close to Bayou du Large, and removed from the mound (16Tr3) by several hundred feet. Drainage canals excavated during the last few years unearthed two Rangia shell middens that may be contiguous. These middens are located between the mound and Bayou Mauvais Bois. The middens were completely buried by sediments from Bayou du Large. From the ground surface to the crest of the portion of the middens exposed in the excavated trench was over four feet in thickness.

Site 16Tr38 consisted of three earthen mounds, one of which has been destroyed. They are located on the west bank of Bayou Grand Caillou about one mile south of its connection with Bayou LaCarpe. Altschul's (1978) field testing of this site indicated it to have been occupied during Plaquemine Period times.

Altschul (1978) interpreted 16Tr2 (Sanders) and 79 (Bergeron) as being of little significance. Site 16Tr2 was not located during Altschul's survey and the latter was reported as destroyed in the plow zone. Site 16Tr26 was listed by Altschul as being potentially significant. It is located in a plowed field and its condition is indicated as destroyed or submerged.

Site 16Tr63 is located on Bayou Blue and Altschul indicates it to be in good condition. He classifies this site as highly significant. It is described as comprising small earth mounds and recommends that the site be investigated and preserved.

To develop a comprehensive plan for management of the cultural resources in Terrebonne Parish will require field investigations to determine status of existing sites regarding location, integrity and research value. Understanding the sequence of occupation within established chronological periods through time and social structure and interrelationships of Indian groups living contemporaneously on the bayous has only begun.

4.1.3.3 Other Programs in the Area. Relationship of the proposed parish-wide forced drainage project to other programs in the area is presented in Table IV-16. It is not anticipated that the proposed forced drainage program will conflict with any existing or future land use plans for Terrebonne Parish. Development opportunities may increase with the construction of proposed projects, resulting in a probable increase in demand for public services.

Executive orders 11988, "Floodplain Management" and 11990, "Protection of Wetlands" direct federal agencies "to avoid, to the extent possible, all actions associated with the modification or destruction of floodplains and wetlands or actions that may increase the risk of loss of life or property resulting from flood or storm damage".

EDA Directive 17.04, dated March 6, 1979, establishes the agency's policy and procedures for implementing these Executive Orders. The stated EDA policy in this regard is to: (1) avoid, to the extent practicable, the long and short term impacts associated with the modification and occupancy of floodplains and wetlands; (2) avoid, to the extent practicable, direct and indirect impacts on floodplain and wetland values and functions; (3) promote the use of non-structural flood protection methods to reduce the risk of flood loss; (4) minimize the impact of

TABLE IV-16. Relationship of the Proposed Parish-Wide Forced Drainage Projects to Environmental and Statutory Requirements

REQUIREMENTS	APPLICABILITY
Section 9 of River and Harbor Act (R&HA) of March 3, 1899	Not applicable
Section 10, R&HA	Full compliance
Section 11, R&HA	Not applicable
Section 13, R&HA	Not applicable
Section 14, R&HA	Not applicable
Section 1 of the River and Harbor Act of 1902	Not applicable
The Marine Protection Research & Sanctuaries Act	Not applicable
Section 401 CWA	Full compliance
National Environmental Policy Act	Full compliance
Fish and Wildlife Coordination Act	Full compliance
Migratory Marine Game Fish Act	Not applicable
Fish and Wildlife Act of 1956	Partial compliance
Federal Power Act of 1929	Not applicable
National Historic Preservation Act of 1966	Full compliance
Endangered Species Act of 1973	Full compliance
Marine Mammal Protection Act of 1972	Not applicable
Wild and Scenic River Act	Not applicable
Land and Water Conservation Fund Act of 1965	Not applicable
Clean Air Act	Full compliance
Floodplain Management E.O. 11988 & 11990	Full compliance
National Flood Insurance Program	Partial compliance
Louisiana Air Control Act	Full compliance

TABLE IV-16. (continued)

REQUIREMENTS	APPLICABILITY
Louisiana Archaeological Treasure Act	Full compliance
Louisiana Historic District Preservation Act	Not applicable. No districts under consideration at the present time.
Louisiana Scenic Streams Act	Full compliance
Louisiana Coastal Resources Program	Full compliance

floods on human health, safety and welfare; (5) restore and preserve the natural and beneficial values and functions of floodplains and wetlands; (6) provide the public with early and continued opportunity for involvement in the decision making process concerning floodplains and wetlands; and (7) incorporate the Unified National Program for Floodplain Management into its decision-making process.

The requirements of the directive and the referenced orders (1198 and 1190) have been considered and addressed in this EIS, since floodplains and wetlands exist in the project area.

Full compliance is indicated by utilizing the wetland/nonwetland interface levee alignment. This assumes that nonwetlands are not in the floodplain. The only exception to this policy occur where: (1) minor wetlands unavoidably encompassed where immediately adjacent to existing developments; (2) where the wetland/nonwetland interface is so irregular as to economically prohibit strict adherence; and (3) extensive areas of wetlands encompassed in project boundaries but are to be managed as wetlands.

The ultimate fate of the 5 unauthorized projects will be determined on an individual basis with the normal public review associated with permit processing.

4.1.4 Economics

4.1.4.1 Population. Preliminary 1980 Bureau of the Census reports indicate a total of 94,733 for Terrebonne Parish, with the greatest concentration in Ward 3 comprising the Houma area (48,125). Ward-by-ward population figures indicate that the next largest total is the 14,195 for Ward 1 encompassing Gray and Schriever (see Table 1, Appendix G, all appendices were published only in the Draft EIS and may be secured from the New Orleans District).

In 1830 when the first census of Terrebonne Parish was taken, the population was comprised of 1,088 individuals. By 1930, census figures reported a total of 39,816 inhabitants. The figures for 1940 and 1950 were 35,880 and 43,328 respectively.

Terrebonne's population has nearly tripled since 1930. The largest jump in population occurred between 1950 and 1960 (60,771), representing a 10-year growth rate of 40.3 percent. The increase from 60,771 in 1960 to 76,049 in 1970 represented a 25 percent increase, and the increase between 1970 and 1980 census figures similarly amounted to nearly 25 percent. See Table 2, Appendix G for population trends and projections.

Population density in Terrebonne Parish as of 1980 was about 56.7 people per square mile. Concentrations of population may tend to spread out into areas now undeveloped because of proneness to flooding, as a result of implementation of the proposed project.

4.1.4.2 Income. The prosperous nature of the parish's economy is reflected in per capita income and consumer spendable income figures shown in Table 3 of Appendix G. Terrebonne's per capita income in 1978 of \$7,504 ranked the parish fifth in Louisiana. Figures also indicate that the largest number of households in Terrebonne (30.8%) ranked in the income range of \$25,000 and over during 1979 (Table 3, Appendix G).

Economic indicators for any area include scrutiny of assessed property valuations and tax collections. Table 4, Appendix G indicates the growth in assessed valuations for a period from 1960 to

1979; reassessment of January 1, 1978 accounted for the \$73,074,465 amount of increase, or the 43.59 percent increase that year, which was by far the largest growth increase in that time frame. That table also indicates that \$252,899,740 was the assessed valuation for the parish for 1979.

Parish and local taxes for 1979 totaled \$19,629,392.78 (Table 5, Appendix G); that table indicates a complete analysis of tax millages for the year 1979.

A comparative statement showing total assessments for Terrebonne and Louisiana, indicating a pertinent percentage of the parish toward the state total for the years 1972 through 1977, is reflected in Table 6, Appendix G.

Particularly salient viewpoints on the parish economy can be derived from the data presented in Table 7, Appendix G, which itemizes and gives totals for the collections and areas of disbursements by the Sales and Use Tax Office of Terrebonne Parish for the year 1981. Perusal of Table 7 indicates a sound and healthy tax base for the parish, at a time when many parts of the country experienced declines in economic well-being. Table 8, Appendix G continues a comparison of Terrebonne's revenue derived from state tax as a percentage of the total of the state of Louisiana; local property tax levies are indicated similarly for parish and state in Table 9, Appendix G, for the years 1975 and 1976.

Income levels should not be adversely affected by the proposed project.

4.1.4.3 Employment. The labor force of Terrebonne Parish for 1981, as released in preliminary figures in January, 1982 by the Louisiana Department of Labor, equaled 46,825, with 44,450 employed and 2,375 unemployed for an unemployment rate of only 5.1 percent. Labor force data detailed for Terrebonne and the state for 1979 in Table 10, Appendix G indicates the stability of the low unemployment rate, since that year's rate was 5.3 percent for the parish.

Tables 11, Appendix G and 12, Appendix G show the labor force by occupational division and by industry, respectively, for 1979. That year Terrebonne ranked high at seventh among the 64 parishes of Louisiana in average weekly wages, as indicated in Table 13, Appendix G.

Covered employment and total wages paid for each of the 4-digit industry codes during the fourth quarter of 1979 are detailed in Table 14, Appendix G, and Table 15, Appendix G lists the parish's major employers as of April, 1981.

No jobs are likely to be relocated or eliminated because of the proposed project.

4.1.4.4 Commercial Activities

4.1.4.4.1 Wholesale Trade. A comparison of wholesale activity in Terrebonne Parish during the years of 1972 and 1977 (Table 16, Appendix G) reveals that during the intervening five years wholesale sales more than doubled in Terrebonne, escalating from 1972's \$141,473,000 total sales

figure to \$302,431,000 in 1977. Yearly payrolls in wholesale trade doubled also between those two years, from \$11,271,000 to \$22,548,000.

4.1.4.4.2 Retail Trade. A corresponding upward trend in Terrebonne retail trade occurred between 1972 and 1977 as exhibited in Table 17, Appendix G, with both retail sales and yearly payrolls associated with retail trade doubling in the five-year period.

4.1.4.4.3 Manufacturing. Statistics related to manufacturing (Table 18, Appendix G) reveal that value added by manufacture in 1972, \$59.3 million, increased to \$75.8 million by 1977. From the 1981 Directory of Louisiana Manufactures, a list of manufacturing and processing firms in Houma and within a 20-mile radius was compiled as Table 19, Appendix G.

4.1.4.4.4 Construction Activity. Tables 20-23, Appendix G, reflect the extent of City of Houma construction activity through a month-by-month tabulation of residential and commercial building permits issued and amount of construction costs, for the years 1978-1981 (through September). Residential permits issued by the City of Houma in 1979 exceeded the number of such permits issued in the other four years, while the number of commercial permits issued by the city peaked in 1980 for the four-year period. The nine-month 1981 period for which statistics are shown exhibit a considerable slowdown in construction activity, at a time when soaring interest rates and a national period of recession seemed to affect such construction starts in the city.

Tables 24-27, Appendix G, are a tabulation of the same data for all of Terrebonne Parish outside the limits of the City of Houma. Although the greatest number of residential permits for the four years were issued by the parish in 1979 (311), statistics in that category for a nine-month period of 1981 (a total of 217) indicates that the national economy had little effect on such construction; indeed, that total for nine months of 1981 exceeds the number of residential permits issued in all of 1980 (192). And for the nine months surveyed in 1981's commercial permits issued, the total of 106 exceeds all other complete years for which data were gathered.

The parishwide forced drainage project could have only a beneficial effect on the construction industry since it would make secure for construction some areas which now are questionable as to flooding status.

4.1.4.5 General Economic Profile

4.1.4.5.1 Forestry. Forest areas in Terrebonne in 1975 amounted to 9.5 percent of the total acreage of the parish (Table 28, Appendix G). In Table 29, Appendix G one can see totals for species of timber severed in Terrebonne that year. Landowner income from sale of timber as indicated in Table 30, Appendix G was \$36,235 in 1975, a decrease from 1974's total of \$39,775; forestry cannot be considered a major industry, then, in Terrebonne Parish.

4.1.4.5.2 Agriculture. Table 31, Appendix G, indicates that in 1978 Terrebonne Parish had 131 farms at an average size of 494 acres; 7.3 percent of the parish's area was devoted to farmland.

Sugar cane accounted for the largest gross dollar value of farm crops in Terrebonne in 1979 (Table 32, Appendix G), at a total \$4,544,000 value;

value of soybeans was second in gross dollar value at \$2,470,000 and total crop value for the parish was \$8,165,925.

Total animal production in 1979, including fisheries, for the parish amounted to \$35,797,392 in gross value (Table 33, Appendix G).

A decline in total crop production by 1980 in dollar value can be seen in Table 34, Appendix G, with a total for that year only \$1,581,467, and a drastic cut in gross farm value of sugar cane. Animal production for 1980, however, jumped in value from nearly \$36 million the previous year to \$63,797,221 (Table 35).

4.1.4.5.3 Fisheries. Louisiana is a leading state in the number of pounds in the commercial fisheries catch each year, and Terrebonne Parish contributes significantly to the state total. Tables 36-37, Appendix G are included to show pound totals and dollar values of the fisheries catch by year, the latter for a three-year period and the former for a ten-year period (see also Tables 33 and 35, Appendix G). Although figures for the same three years for which statistics are provided in Tables 36 and 37, Appendix G deviate to some extent, they are close enough to give an accurate picture of the dollar value and total pound catch of the parish's fisheries industry, and its importance to the community. The National Marine Fisheries Service's Houma office could not reveal information which included totals for menhaden which could reveal confidential information on an individual producer; perhaps the higher figures and resultant discrepancies in Table 38, Appendix G reflect totals including those figures. Figures 1 and 2, Appendix G provide information in graph form on the entire state's menhaden catch.

According to a publication of the Louisiana State University Center for Wetland Resources, Terrebonne Parish in 1978 had 4,414 fisheries licenses issued by the Louisiana Department of Wildlife and Fisheries (LDWF) or 9.276 percent of the total number of fisheries licenses issued in Louisiana; only Jefferson Parish had more licenses issued, 4,884 or 10.263 percent. The number of resident commercial shrimp trawl and vessel licenses sold by LDWF in Terrebonne in 1978 was 2,482; resident non-commercial shrimp trawl licenses, 1,166; resident commercial crab trap licenses, 66; resident oyster tonnage and resident oyster dredging licenses, 293.

The fisheries industry is vital to Terrebonne's economy and would not to a significant degree be affected by the proposed parishwide forced drainage project.

4.1.4.5.4 Mineral Resources. Mineral resources are extremely important to the economy of Terrebonne Parish, as indicated in Table 39, Appendix G. In order of value the minerals produced in the parish include petroleum, natural gas liquid, sulfur and salt. In the five-year period from 1970 to 1975, the dollar value of mineral production in the parish increased from \$756,968,000 to \$1,265,588,000. Because the 1975 total value of mineral production in Louisiana was \$8,513,275,000, Terrebonne Parish's total production was 14.9 percent of the state's total.

Tables 40 and 41, Appendix G cite further data on oil and gas production in Terrebonne for 1975 and 1976. Severance tax collections for 1976-1977 on oil and other mineral products are contained in Table 42, Appendix G.

As production has increased, needs of the petroleum industry have given impetus to growth in shipbuilding and all types of marine and oilfield supply businesses that provide everything from diving equipment to shore-to-ship catering. Terrebonne Parish has experienced an increase in the need for onshore support bases, platform fabricators, pipe supply yards, ship builders and numerous types of service yards. Houma has developed into a major oil center. About 75 percent of the parish's work force is employed directly or indirectly in the petroleum industry; therefore it is easy to see the importance of this industry to the parish's economy.

Locations of gas processing plants, refineries, shipyards and other sites related to the industry within Terrebonne Parish are available in map form as compiled by U.S. Department of the Interior, Bureau of Land Management. The maps are on file at the offices of T. Baker Smith & Son, Inc. and are available for review.

4.1.4.5.5 Transportation. (1) Waterways, highways, railways, air transportation--All major features having to do with ground, air and water transportation features in Terrebonne Parish are available in map form as compiled by U.S. Department of the Interior, Bureau of Land Management. The maps are on file and available for review at T. Baker Smith & Son, Inc. offices; and (2) Pipelines--The complex system of buried pipelines owned and operated by oil companies and pipeline companies are depicted in map form as compiled by U.S. Department of the Interior, Bureau of Land Management. The maps are on file at the offices of T. Baker Smith & Son, Inc. and are available for review. The pipelines transport oil and natural gas from offshore producing wells to onshore refineries and eventually to consumers throughout the country.

4.1.4.5.6 Conservation/Preservation/Recreation. Features of each of these categories which are located within Terrebonne Parish are illustrated in map form as compiled by U.S. Department of the Interior, Bureau of Land Management. The maps are on file at the offices of T. Baker Smith & Son, Inc. and are available for review.

4.2 Saline Marsh. Only three acres of saline marsh lie within the project areas; however, there are extensive areas of saline marsh bordering projects 4-3C and 5-4 (Appendix A). Projects 4-3B, 8-1 (unauthorized) and 3-2 (unauthorized) lie just to the north of saline marsh and may impact this habitat type (Appendix A). Overall, saline marsh excluding associated water bodies encompasses 120,220 acres or 8.9 percent of Terrebonne Parish (Wicker *et al.* 1980). These figures include the mangrove shrubs along the coastline which are recognized as a different habitat than saline marsh but are small in areal extent and will not be affected by the proposed or unauthorized projects.

4.2.1 Physical.

4.2.1.1 Meteorological and Climatological. The saline marsh, because of its southern location in the parish and its proximity to the coast, experiences a somewhat drier climate year-round but lower deficits during summer than wetland habitats in the northern part of the parish. This expected coastal modifying effect is discussed in Section 4.1.1.5 and additional general climatic information is presented in Section 4.1.1.1.

4.2.1.2 Topological. The elevational range of the salt marsh is a function of tidal range (Adams 1963; Baumann 1980). Due to the low tidal range along the coast of Terrebonne Parish, the elevation range and variability is also low. Based on measurements of marshes in the Cocodrie and Caillou Lake areas (Sasser 1977) the mean elevation of the saline marsh closely approximates local mean water level conditions with a deviation of about +15 percent. (Also see Section 4.1.1.2.)

4.2.1.3 Geological. The extensive salt marshes of Terrebonne Parish provide a morphologic indicator that the deltaic systems that formed the parish are undergoing the deterioration phase of the Mississippi River deltaic cycle. Conversely, the general reduction in salt marsh habitat in the extreme western section of Terrebonne Parish is a result of the influence of the Atchafalaya system which is currently on the progradational phase of the delta development cycle. Section 4.1.1.3 contains a more complete discussion of the important geologic processes affecting habitat development and variability.

4.2.1.4 Soils. Table IV-5 provides a listing of major soil types within the saline marsh, and soil type descriptions are included in Section 4.1.1.4.

Free water soil salinities average 12.4 ppt and reach 32 ppt (Chabreck 1972). Organic content of saline marsh soils in Terrebonne Parish averages 16 percent on a dry weight basis (Chabreck 1972). Among coastal wetland soils, saline marsh typically contains the highest inorganic to organic ratios, which is a result of the higher energy conditions in the form of flushing (tides) and waves that exist at the coast in comparison to the fresher marshes farther inland. Normal tidal action and storms have a wet effect of transporting inorganic material to the marsh and organic material from the marsh (Baumann 1980; Hupp *et al.* 1977; Delaune *et al.* 1978). Gosselink *et al.* (1979) have estimated that the saline marsh exports 30 percent of its net organic production. (Also see Sections 4.1.1.4 and 4.2.2.3.)

4.2.1.5 Hydrological. Saline marshes are influenced by tidal action to a greater extent than are any of the other wetlands. One result of the greater influence of tides is a regular inundation regime. Saline marshes in the nearby Barataria Basin are flooded approximately 50 percent of the time. Frequency of flooding averages about 20 events per month with only slight seasonal variability, but the duration of flooding has a pronounced seasonal pattern with the longest duration typically occurring during the September-October period (Baumann 1980). (Also see Section 4.1.1.5 and 4.2.2.3.)

4.2.1.6 Water Quality. In general, waters in the saline marshes of Terrebonne Parish are least affected by point-source and non-point source discharges. This is mainly due to their distance from the population centers. Water quality is discussed more fully in a regional context in Section 4.1.1.6.

4.2.1.7 Air Quality. There are no representative air quality monitoring stations for the saline marsh. (See Section 4.1.1.7.)

4.2.2 Biological.

4.2.2.1 Flora. The major emergent macrophytes of the saline marsh are Spartina alterniflora, Distichlis spicata, Juncus roemerianus and S. patens (Chabreck 1972). Species diversity is low in comparison to the other marsh types, a factor which is attributed to the stressing influence of saltwater (Gosselink et al. 1979). A listing of species found on the saline marsh of Terrebonne Parish and their relative abundance is included in Section 4.2.2.3. Species that are important food sources for wildlife are included in Appendix E.

4.2.2.2 Fauna. Similar to the flora characteristics, species diversity is lower in the saline marsh than in the other wetland habitats (Gosselink et al. 1979). The saline marsh in general supports fauna similar to the other wetland habitats, except in lower densities. This is true for such mammals as raccoons, opossum, and rabbits and for reptiles such as the alligator and for many species of waterfowl. The aquatic environment of the saline marsh is an important nursing ground for the commercial gulf menhaden, shrimp and blue crabs. Oyster production is an important industry in the saline marshes of Terrebonne Parish. A more detailed discussion of the functionally important species and species lists are included in Section 4.2.2.3; Appendix F contains a listing of endangered fauna.

4.2.2.3 Ecology. Wicker et al. (1980) determined from measurements of 1978 aerial photography that Terrebonne Parish contains approximately 120,220 acres of saline marsh as described by Chabreck and Linscombe (1978). Salt marsh lies adjacent to the Gulf of Mexico and is subject to daily tidal fluctuations. Chabreck (1980) describes saline marsh of the Deltaic Plain as being dissected by numerous embayments and tidal inlets, which results in rapid and drastic tidal action.

The tidal cycle in the coastal areas of Louisiana is controlled largely by tides in the Gulf of Mexico which can be further influenced by local conditions. At any location the tides not only vary in range from day to day, but also from month to month and year to year. The tides are affected by the gravitational attraction of the moon, sun, and other astronomical bodies. Approximately 24 hours and 50 minutes constitute a tidal period, which is the interval of time between two consecutive occurrences of the same tidal phase (Coastal Engineering Research Center 1973).

A diurnal tide is one that has one high water and one low water in a tidal day. Gunter (1967) reported that at the beginning of the cycle, tides are normally the daily type with one maximum and one minimum each day. The maximum fluctuation is 26 inches which occurs only once a month, then every succeeding day it declines slightly until the variation is only two or three inches a day with the tide standing a little above mean low.

The semidaily tides have two high waters and two low waters in a tidal day, with an interval between highs of about 12 hours and 30 minutes (Marmer 1954).

The periodic rise and fall of the tide is subject to the effects of changing weather conditions (meteorological tides) (Wax, Borengasser, R.A. Muller 1978). Livingston and Locks (1978) found that production and food-web relationships in wetlands and their downstream dependent systems are governed in part by regional climatic and hydrological characteristics of the watersheds in which they are situated. The wetland and its surrounding landscape (watershed) thus determine nutrient and energy transport, gradients of physiochemical variables, and timing of responses in the wetland as well as adjacent systems. With strong southerly winds, Gulf waters move inland through the many bays, bayous and canals. Periods with prolonged winds frequently result in inundation of the marshes. During periods of low mean tide level, it may be that the only tides which can flood the marsh are those due to wind. At such times the frequency and duration of winds from various directions can be of critical importance to maintenance of marsh biota found in differing hydrographic circumstances (Day et al. 1973).

During the winter strong northerly winds move water out and at times tides as low as two feet below normal are not uncommon. Marshes drained by tidal channels will be practically dry at such times. Gunter (1967) reported that heavy local rainfall has a slight disturbance on tide levels in back bays, but the effects are only temporary. Periods of high water during rainy seasons in adjacent upland areas may curtail the tidal effect in the marsh waterways until the freshwater level is lowered to that of the current high tide level.

Water salinities average 17.37 ppt (range 8.07 to 32.39 ppt) and soils have a lower organic content (mean 16.57%) than marsh types located farther inland (Chabreck 1972). Of all marsh types the saline marsh contains the lowest diversity of plant species (Table IV-17). The low level of organic matter in soil (substrate) of saline marsh is associated with tidal regimes of that type. The greater fluctuating tide levels result in greater exposure of marsh soil to air, thus greater oxidation of organic matter. Delaune et al. (1976) described the importance of soil oxygen content and its impact on nutrient transformations in Louisiana salt marsh soils. Also, the sweeping action of tides in saline marsh, resulting from the frequent rise and fall, carries organic debris deposited on the marsh surface to tidal channels, then to downstream lakes and bays. The particulate detritus remains suspended in the water and, in many instances, comprises the bulk of the particulate organic load (i.e., seston) of water. Seston of coastal waters in general is 75 to 95 percent detritus (de la Cruz 1973). Also, saline marsh contains a greater number of marsh detritivors (e.g., fiddler crab, Uca pugnax) and the foraging of this group removes much of the plant debris deposited on the marsh surface. Most mineral soil currently deposited in marshes of the parish is brought in from the Gulf of Mexico by tidal action. Since saline marsh is the zone closest to the Gulf, it receives the greatest amount of sedimentation from this source. This addition of mineral soil, then somewhat limited, functions to reduce the ratio of organic matter in saline marsh.

Primary productivity is high and usually takes the form of vascular vegetation (grass, rush, sedge, mangrove), epiphytic or sediment attached algae, intertidal grasses and benthic algae (largely diatoms).

TABLE IV-17. Plant Species Composition of Vegetative Types in Hydrologic Unit V

Common Name	Scientific Name	Saline	Vegetative Type		
			Brackish	Intermediate	Fresh
Alligatorweed	<u>Alternanthera philoxeroides</u>				
Aster	<u>Aster sp.</u>			1.12	2.42
Black mangrove	<u>Avicennia nitida</u>	1.52			
Water hyssop	<u>Bacopa monnieri</u>			3.72	
Batis	<u>Batis maritima</u>	6.58			
Flatsedge	<u>Cyperous ordoratus</u>		2.31	2.98	1.92
Swamp Loosestrife	<u>Decodon verticillatus</u>				1.10
Saltgrass	<u>Distichlis spicata</u>	11.66	13.09	1.86	
Southern marsh fern	<u>Thelypteris palustris</u>				1.43
Walter's millet	<u>Echinochloa walteri</u>			2.60	
Spikerush	<u>Eleocharis sp.</u>		1.93	1.27	18.03
Water pennywort	<u>Hydrocotyle umbellata</u>				4.32
Morning glory	<u>Ipomoea sagittata</u>			1.12	
Black rush	<u>Juncus roemerianus</u>	3.69			
Bearded Sprangletop	<u>Leptochloa fascicularis</u>			9.23	
Southern naiad	<u>Najas guadalupensis</u>			3.35	

TABLE IV-17 (continued)

Common Name	Scientific Name	Saline	Vegetative Type		
			Brackish	Intermediate	Fresh
Royal fern	<u>Osmunda regalis</u>		1.49		
Maidencane	<u>Panicum hemitomon</u>		4.09		42.17
Seashore paspalum	<u>Paspalum vaginatum</u>		2.98		
Roseau	<u>Phragmites communis</u>		1.49		
Camphorweed	<u>Pluchea comphorata</u>		3.12		1.19
Bulltongue	<u>Sagittaria falcata</u>		2.45		7.67
Three-cornered grass	<u>Scirpus olneyi</u>		6.57		
Softstem bulrush	<u>Scirpus validus</u>		1.50		
Oystergrass	<u>Spartina alterniflora</u>	67.73	2.08		
Hogcane	<u>Spartina cynosuroides</u>		1.13		
Wiregrass	<u>Spartina patens</u>	6.81	63.39	34.23	1.22
Cattail	<u>Typha spp.</u>		5.95		1.58
Deerpea	<u>Vigna luteola</u>		7.07		1.04
Giant cutgrass	<u>Zizaniopsis milaceae</u>				3.18
Other species ^a		2.01	3.92	2.81	10.00

Source: Chabreck, 1972.

^aIncludes only plants making up less than 1.00 percent of the species composition.

Spartina alterniflora is the most common salt marsh plant in the project area with a 68 percent occurrence. In a study of the Barataria Basin, Day et al. (1973) determined the production of Spartina alterniflora along streamside attained a maximum biomass of 925 g dry wt/m², while an area 50 meters inland reached a maximum biomass of 660 g dry wt/m². Both reached their maximum biomass in September. Figure IV-26 shows marsh grass community links as described by Wass and Wright (1969).

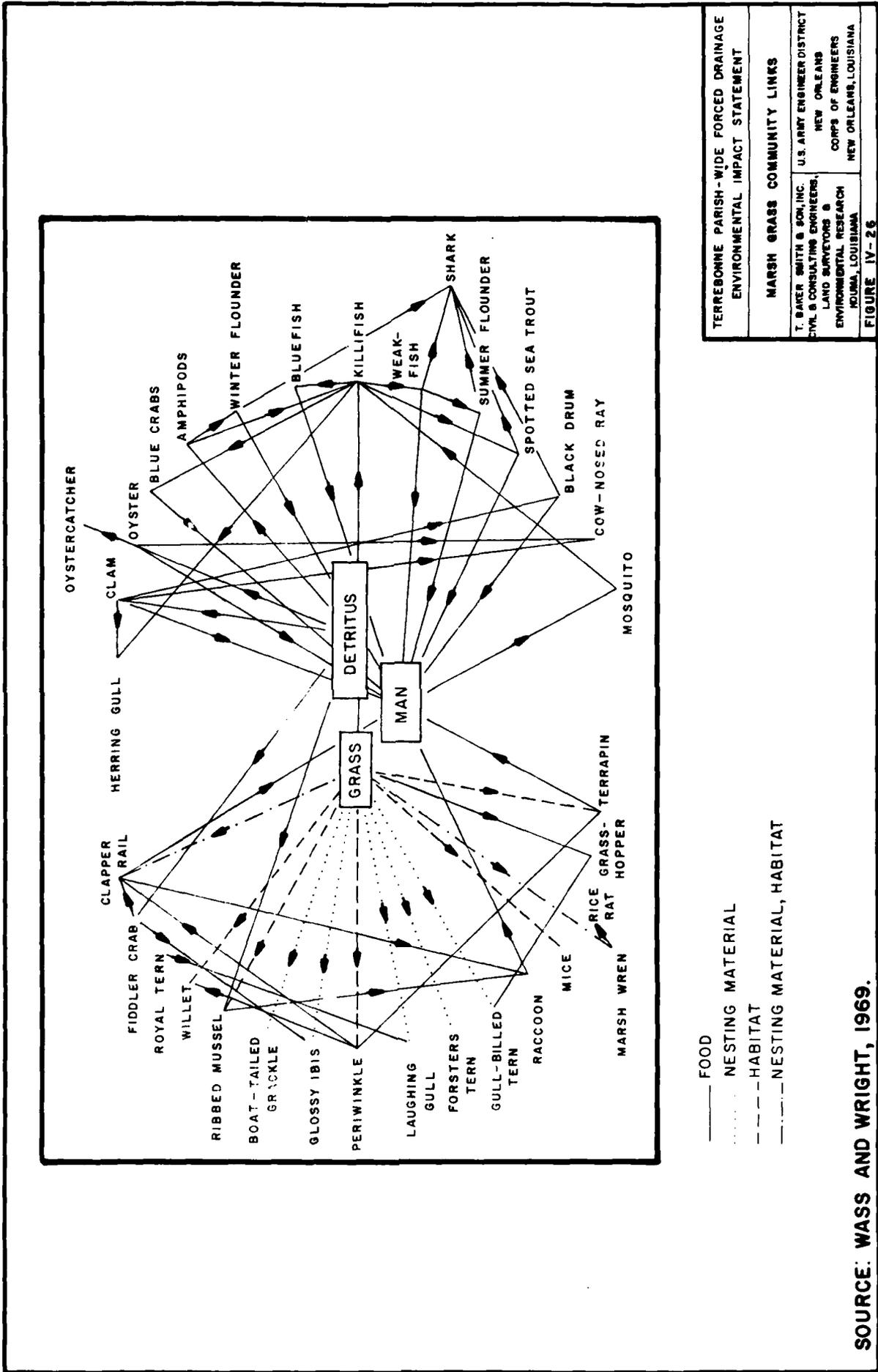
Stowe (1972) studied epiphytic algae on Spartina alterniflora and Avicennia germinans within the Barataria Basin. He determined the major filamentous forms were Bostrychia, Polysiphonia, Enteromorpha and Ectocarpus. The non-filamentous algal groups were composed almost exclusively of diatoms. Both alga forms along with detritus and bacteria provide a food source for protozoa and meiobenthos including ciliates, foraminifera, hemotodes, digochaetes, polychaetes and small crustaceans (Day et al. 1973).

Day et al. (1973) found mollusks were the predominant larger organism at 10 meters into the marsh. These included three species of snails and one species of mussel. Snails included the marsh periwinkle (Littornia irrorata), Smooth periwinkle (Neritina reclinata) and the snail (Melampus bidentata). It was learned by Day et al. (1973) that these snails fed upon the epiphytic algal film on the plants and marsh floor. The ribbed mussel (Modiolus demissus) was found to feed on suspended detritus, algae, zooplankton and other material which become suspended or flushed in by the tides.

De la Cruz (1979) described the energy flow of a salt marsh following a Y-shaped pathway resulting from a grazing food chain (GFC) and a detritus food chain (DFC) (Figure IV-27). Patterns of wetland primary production and the distribution of consumer habitat ultimately determine the principal groups contributing to secondary production and their role in food-web organization. The primary consumers of the GFC are herbivores (mainly insects and rodents) which feed on living marsh plants. There are few consumer species in this food chain and they transform energy seasonally.

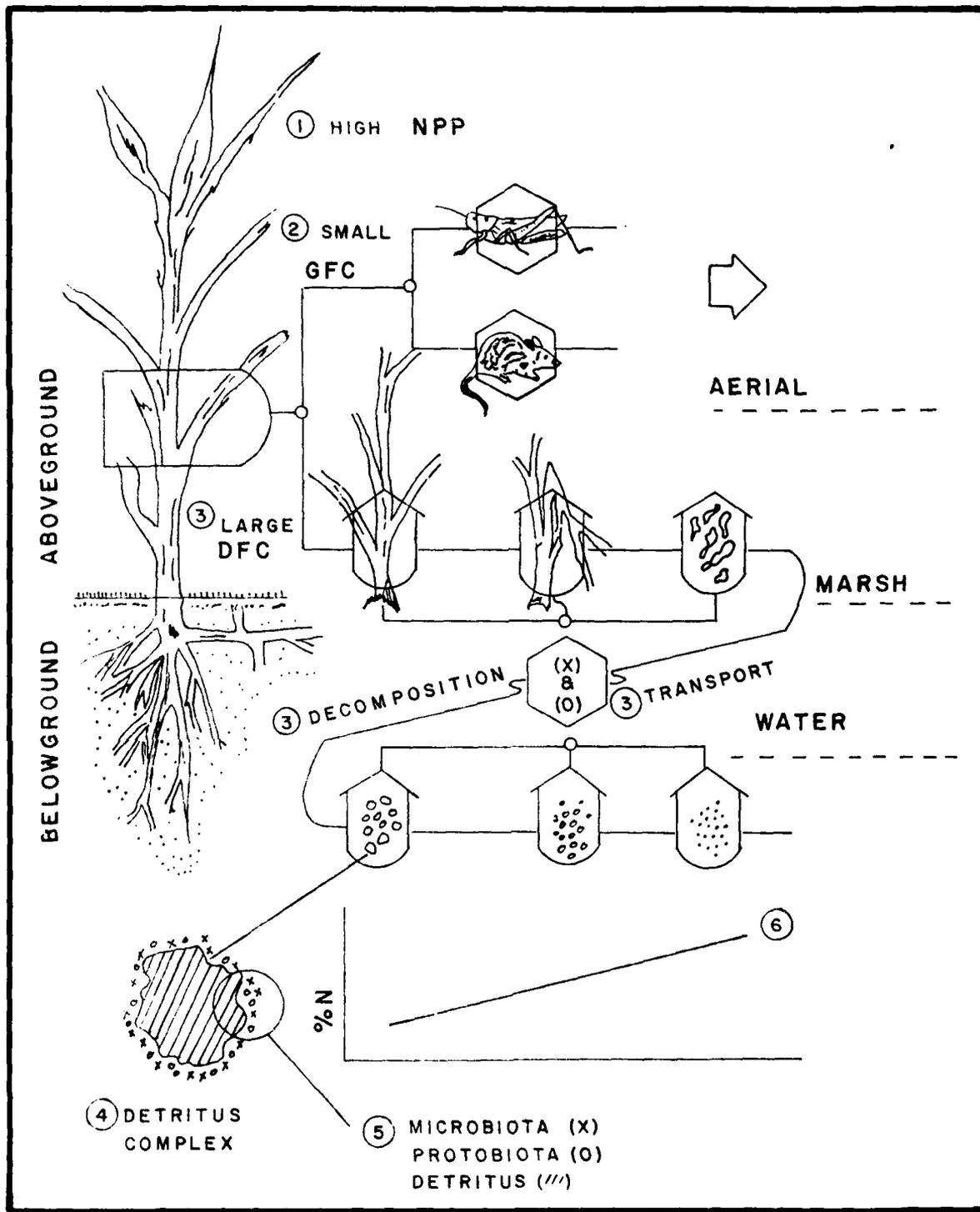
The primary consumers of the DFC feed on the marsh plant detritus derived from decomposing dead plant tissue in the water on the marsh floor. Animals invade and eat the detritus, fragmenting it into smaller particles, or graze on the attendant bacteria and fungi. The resulting feces are rapidly recolonized by microorganisms. There is a gradual decrease in particle size and detritus biomass, with simplification of chemical structure. Caloric and nutrient analysis data obtained from decomposing tissues of Spartina alterniflora, Juncus roemerianus, and other estuarine wetland species indicated that energy and protein values remain high, and in most cases increase, during decomposition to particulate detritus (de la Cruz 1978). The energy flow of these populations is more constant throughout the year since detritus is produced continually, allowing development of an extensive food web with many types of primary and secondary consumers (Keefe 1972).

Particulate detritus, suspended in the water and deposited on the sediment surface, is a high quality food source readily available to consumers anywhere in the estuary and adjoining marine areas. Studies involving stomach analyses and experimental feeding using radioactive



TERREBONNE PARISH - WIDE FORCED DRAINAGE ENVIRONMENTAL IMPACT STATEMENT	
MARSH GRASS COMMUNITY LINKS	
T. BAKER SMITH & SON, INC. CIVIL & CONSULTING ENGINEERS, LAND SURVEYORS & ENVIRONMENTAL RESEARCH MOBILE, LOUISIANA	U.S. ARMY ENGINEER DISTRICT NEW ORLEANS CORPS OF ENGINEERS NEW ORLEANS, LOUISIANA

SOURCE: WASS AND WRIGHT, 1969.



NPP - NET PRIMARY PRODUCTIVITY
 GFC - GRAZING FOOD CHAIN
 DFC - DETRITUS FOOD CHAIN

SOURCE: de la CRUZ, 1979.

TERREBONNE PARISH-WIDE FORCED DRAINAGE ENVIRONMENTAL IMPACT STATEMENT	
Y-SHAPED ENERGY FLOW IN A SALT MARSH	
T. BAKER SMITH & SON, INC. CIVIL & CONSULTING ENGINEERS, LAND SURVEYORS & ENVIRONMENTAL RESEARCH HOUMA, LOUISIANA	U.S. ARMY ENGINEER DISTRICT NEW ORLEANS CORPS OF ENGINEERS NEW ORLEANS, LOUISIANA
FIGURE IV-27	

tracers have shown that many species of fish and invertebrates feed wholly or partially on particulate detritus (Darnell 1958; de la Cruz and Kawanabe 1967; and Odum 1970).

At this point, brief discussions of a few important animal groups linked to wetland-derived detritus are in order.

Blue Crabs

Food habits of the blue crab (Callinectes sapidus) have been discussed by Darnell (1958), Odum (1971) and Tagatz (1968). Darnell found that the adult diet consisted of (% by volume): crabs and crustacea--10%; mollusks--63%; fish remains--5.4% and organic detritus--8%.

Both Perret (1967) and Foreman (unpublished data) determined the highest biomass peak occurred during the summer. The biomass calculated by Day et al. (1973) ranged from 0.23 g dry w/m² during the summer to low of 0.02 g dry wt/m² during the winter.

Shrimp

"The normal shrimp cycle is now well established and involves the movement of postlarvae into inland waters, thence deep into the shallow nursery areas where they grow rapidly into juveniles. Older juveniles as they increase in size begin a movement into the deeper larger bays and out the passes to offshore waters". (St. Amant et al. 1965)

Brown shrimp postlarvae migrate into the estuaries in greatest numbers during the months of February, March and April. Survival and growth of the postlarvae is apparently strongly affected by temperature and possible salinity (St. Amant et al. 1965). Brown shrimp move offshore during early to mid-summer. Overcrowding and high summer temperatures seem to be the most important factors influencing this offshore movement.

Postlarval white shrimp move into the estuaries in greatest numbers in July and August. Most of the shrimp leave the estuary during November and December. The first movement appears to be due to size and later, there is a general exodus as the temperature drops.

Both brown and white shrimp prefer soft muddy or peaty substrata, while pink shrimp prefer more firm bottoms (Hildebrand 1954; Williams 1958; Kutkuhn 1962).

Shrimp are generally omnivorous, eating plants, animals and inorganic and organic detritus (Farfante 1969). Darnell (1958) found shrimp in Lake Pontchartrain, Louisiana consumed detritus and ground organic matter (58%), small mollusks (12%), and microcrustacea (4%). Lindall et al. (1972) reported that there are some indications that algae provides an important part of the diet of white shrimp in Louisiana waters.

Shrimp biomass is dependent on a number of factors such as temperature and salinity levels. Jacob and Loesch (1971) determined the average biomass for brown shrimp at Airplane Lake in the Barataria Basin for the years 1969 and 1970 was 0.075 g dry wt/m².

Oysters

Oysters are filter feeders and observations of various investigators indicate that diatoms, dinoflagellates and other groups of phytoplankton and zooplankton plus bacteria and organic detritus comprise the diet of the oyster (Van Sickle et al. 1976). Research along the Louisiana coast by Owen (1955) indicated that "at all times and at all stations sampled there were sufficient numbers and kinds of micro-organisms present in the water to support existing populations of oysters". Day et al. (1977) and Galtsoff (1964) calculated an average oyster biomass of 93.5 g org/m².

Fishes

Day et al. (1973) collected fish samples in Caminada Bay located within the Barataria Bay area to determine biomass, seasonal abundance, food habitats and growth rates of fishes in the area (Appendix F). Stomach content analyses of fish have proved useful in revealing ecological relationships among various organisms in the estuarine food web (Darnell 1958, 1961 and Odum 1971). Using data from Odum (1971), Day et al. (1973) classified fish species collected into several trophic levels Appendix F. Perret et al. (1978) conducted seine and trawl samples to determine fish species present in six coastal study areas along the Louisiana coast. Appendix F contains a list of those species collected in coastal study areas IV and V which include Terrebonne Parish.

Day et al. (1973) determined the biomass in Barataria and Caminada Bay was highest in spring and late summer periods, lower during the fall and lowest during the winter. Data by Hellier (1962) and Jones et al. were used by Day et al. to calculate an average annual standing crop biomass of 1.17 g dry wt/m² for the Barataria area.

Methods by Allen (1951) and Ricker (1946) were used by Day et al. to calculate a total yearly fish production of 72.8 g/m²/year.

Day et al. (1973) made some general conclusions from studies done on the food habits of the most common fishes in the Caminada Bay area. It was found that organic detritus is the major component of the herbivorous fishes. Fishes at the higher trophic levels may utilize detritus somewhat, but ingestion may be accidental. Little utilization of phytoplankton was observed, lending further evidence that nutrition in the Barataria Bay area is based on allochthonous organic detritus such as Spartina and other marginal marsh macrophytes. The microbenthos including small crustaceans and insects comprised the main diet of the mid carnivores. The top carnivores, represented by sand seatrout and speckled seatrout, feed largely on the fishes of lower trophic levels and macrobenthic forms such as blue crabs and penaeid and caridean shrimp.

Birds

Day et al. (1973) determined average bird biomass for different trophic groups in the Barataria Bay area (Appendix F). Food habits of principle estuarine birds are indicated in Appendix F. Lowery (1974), Bull and Farrand (1977) and Peterson (1980) provide detailed descriptions of habitats, ranges, food preferences, nesting and seasonal distributions of resident and migratory birds which occur in the project area.

Mammals

Mammals which are important in the marsh are the raccoon, muskrat and nutria. Raccoons are true omnivores and their diet includes plant material, crabs, snails, fish, bird eggs and mussels (Stains 1956; Stuewer 1943; Whitney and Underwood 1952; Martin et al. 1939; and Bateman 1966). Day et al. (1973) estimated marsh population density of raccoons, at 0.25/acre. Day et al. (1973), using this density, calculated raccoon biomass in the Barataria Bay area at 0.028 grams wet wt/m².

Newsom (1971) counted 0.025 muskrat houses per acre in a Barataria Bay salt marsh. O'Neil (1949) gives an average of five muskrats per house and an average weight of 1000 grams wet wt. per individual. Using these data, Day et al. (1973) calculated a density of 0.125 muskrats/acre or 0.031 g wet wt/m². Nutria are about 1/5 as abundant as muskrat in the salt marshes. Mink is found in the salt marsh and Day et al. calculated its biomass to be 0.0056 g wet wt/m². Otters are probably about as abundant as mink (Holcombe 1980).

4.2.2.4 Areas of Special Concern. Special areas within the saline marsh that derive special attention based in criteria listed in Section 4.1.2.4 include:

Lower Four League Bay - prime shrimp nursery
Caillou Lake - oyster seed grounds
Barrier Islands - bird rookeries, function as storm barriers by
absorbing storm wave energy
Bay side of Barrier Islands
Lake Pelto, Old Lady Lake and
southeastern shore of
Timbalier Bay - submerged marine grass beds

4.2.3 Social

4.2.3.1 Land Uses. Except for oil and gas facilities and transportation corridors (canals), the salt marsh is primarily in a natural state. (Also see Section 4.1.3.1.)

4.2.3.2 Cultural Features. Present settlement is primarily limited to isolated groups. During the prehistoric period the present area of saline marsh consisted of fresher habitats and was heavily utilized by Indians (see Section 4.1.3.2.)

4.2.3.3 Other Programs in the Area. See Section 4.1.3.3.

4.2.4 Economic. Major revenues associated with the saline marsh are derived from resource harvests which include: (1) mineral extraction (2) commercial trapping and fishing and (3) recreational fishing and hunting. Other economic values of the saline marsh are realized in the form of cost savings such as its ability to absorb storm energy, thereby reducing the need for structural controls. Lugo and Brinson (1978) provide a listing of passive economic values of saline marshes in general (Table IV-18). Precise economic values of the saline marsh of Terrebonne Parish and elsewhere are extremely difficult to derive and are currently part of an examination of the Mississippi Deltaic Plain region sponsored by the U.S. Fish and Wildlife Service, Office of Biological Services,

TABLE IV-18. Qualitative List of Values of Salt Water Wetlands

Water

store flood waters
conserve water during droughty periods
desalinate salty water

Organic Productivity

high primary productivity
high secondary productivity (e.g., commercial and sport fisheries)
high export of organic foods to other ecosystems
high wood production (in forested salt water wetlands)

Biogeochemical Values

high capacity to recycle nutrients
high storage of organic matter and CO₂ sink
net oxygen production
many biogeochemical cycles are closed by reducing N,C,S,Fe, etc., in anaerobic muds
heavy metals, radioactive isotopes, and other poisonous chemicals are sequestered in anaerobic muds

Geomorphological Values

high potential for erosion control
protection of coastlines against storms, tides and winds
high potential to build land

Biotic Values

serve as fisheries nurseries, bird rookeries, and refuges for terrestrial animals
gene banks for haline and euryhhaline plant and animal species

Other Values

natural laboratories for teaching and research
location for recreation and relaxation
rich organic soils used for agriculture, aquaculture, or as fuels
location for solid waste disposal or construction activities
importance as natural heritage, particularly when they become scarce
representative of personal intangible values

Slidell, Louisiana. (Also see Section 4.1.4.)

4.3 Brackish Marsh. There are 874 acres of brackish marsh within the project areas. Project 8-1 (unauthorized) contains 760 acres, and projects 3-2 (unauthorized), 4-2B and 4-3C contain the remaining 114 acres. Additional extensive areas of brackish marsh border the above project areas. Overall, Terrebonne Parish contains 122,315 acres of brackish marsh excluding associated open water bodies, or approximately 9.1 percent of Terrebonne Parish (Wicker et al. 1980).

4.3.1 Physical.

4.3.1.1 Meteorological and Climatological. The brackish marsh areas can be expected to be strongly influenced by the coastal climatic factors discussed in Section 4.1.1.5. Additional general climatic information is presented in Section 4.1.1.1.

4.3.1.2 Topological. Elevation of the brackish marsh in Terrebonne Parish is controlled primarily by local water levels with mean marsh elevation being close to but slightly greater than mean water level (Sasser 1977). Elevation variability is slight, as water level variability including tides is low. (Also see Section 4.1.1.2.)

4.3.1.3 Geological. Brackish marshes are generally associated with high land loss rates (Wicker et al. 1980). As shown in Section 4.1.1.3, the area of brackish marsh and associated water bodies in Terrebonne Parish has experienced a net increase during 1968-1978 at the expense of intermediate and fresh marshes which in turn has offset the decreases in brackish marsh to saline marsh. Once the fresher marshes are converted to more brackish conditions the transformation from marsh to open water is fairly rapid. For a more complete discussion of the important geologic processes affecting habitat development and variability, refer to Section 4.1.1.3.

4.3.1.4 Soils. Soil type descriptions are included in Section 4.1.1.4 and a listing of the major soil types by habitat type including brackish marsh is provided in Table IV-5.

Free water soil salinities average 5.1 ppt but are highly variable (Chabreck 1972). Mean organic content of brackish marsh soils is 43 percent on a dry weight basis (Chabreck 1972) and approximately 13 percent of net production of organics is exported out of the brackish marsh (Gosselink et al. 1979). The higher percentage content of organics in the soil and the lower percentage of exports in the brackish marsh as compared to the saline marsh are attributed to differences in the inundation regime and energy level conditions (Gosselink et al. 1979). (Also see Section 4.1.1.4 and 4.3.2.3.)

4.3.1.5 Hydrological. Flooding of the brackish marsh is dependent on wind and astronomical tides, seasonal gulf level cycles and local rainfall. The brackish marsh is flooded approximately 50 percent of the time but at a lower frequency and longer duration per flood event than the saline marsh (Sasser 1978). (Also see Sections 4.1.1.5 and 4.3.2.3.)

4.3.1.6 Water Quality. Water quality is treated in a regional context in Section 4.1.1.6.

4.3.1.7 Air Quality. There are no representative air quality monitoring stations for brackish marsh. (see Section 4.1.1.7.)

4.3.2 Biological.

4.3.2.1 Flora. The major emergent macrophytes of the brackish marshes of Terrebonne Parish are Spartina patens and Distichlis spicata (Chabreck 1972). Species diversity is greater than in the salt marsh but lower than fresh or intermediate marsh (Gosselink et al. 1979). Net primary production is typically highest for brackish marsh among the coastal marsh habitats (Gosselink et al. 1979). A listing of emergent plants found in the brackish marsh and their relative abundance is provided in Section 4.2.2.3. Species that are important food sources for wildlife are included in Appendix E.

4.3.2.2 Fauna. The brackish marsh habitat is the most saline area in which amphibians occur in appreciable numbers (Gosselink et al. 1979). Muskrats are most abundant in brackish marshes (O'Neil 1949). These marshes also serve as important nursery grounds for sport and commercial species. Species lists as well as discussion of the functionally and commercially important species are provided in Section 4.3.2.3, and Appendix F contains a listing of endangered fauna.

4.3.2.3 Ecology. Brackish marsh is further removed from the influence of high saline Gulf waters than salt marsh but is still affected by daily tidal action. Sustained winds are probably the most important factor in marsh flooding. Brackish marsh is the most extensive and productive of all wetland types and according to Wicker et al. (1980) comprises approximately 122,365 acres in Terrebonne Parish. Normal water depths exceed those of salt marsh, and soils contain higher organic content (mean 43.21%) (Chabreck 1972). Bahr and Hebrard (1976) found high levels of organic carbon and organic nitrogen in brackish soils of the Barataria Basin. They also noted maximal sulfide content, indicating a strongly anaerobic regime below the surface layer. Water salinities in the project area average 7.61 ppt (range 2.42-18.50) (Chabreck 1972).

Brackish marsh contains a higher plant diversity than salt marsh but is dominated by two perennial grasses, Spartina patens and Distichlis spicata (see Table IV-17 in Section 4.2.2.3) (Chabreck 1972).

The brackish marsh may be a zone where fine particulate organic and inorganic matter is trapped. As fresh water flowing gulfward mixes with higher saline water, the ionic constituents of the saline water tend to flocculate fine suspended particles in fresh water, which then settle out (Bahr and Hebrard 1976). Bobo and Patrick (1979) determined if water flow is impeded (by vegetation) at the point of fresh-salt water contact, very slow-moving stratified layers can occur. This effect coupled with the greater chance of flocculation (because of a sharp fresh-salt boundary and slow moving water) can result in very rapid sedimentation in these areas of the marsh.

The brackish marsh has the greatest live biomass of any marsh type. Bahr and Hebrard (1976) estimated the annual overall net primary production for brackish marsh in the Barataria Basin to be about 0.22 lb/ft². Table IV-19 indicates the estimated net primary production per square meter for brackish marsh habitat in Louisiana. Stone (1980) utilized methods from Smalley (1958) and Weigert and Evans (1964) to calculate net primary marsh vegetation production at four sites along Lake Pontchartrain (Table IV-20). The Weigert and Evans method is considered to be more accurate because it accounts for loss of dead material as well as for changes in live and dead standing crop (Kirby and Gosselink 1976; White *et al.* 1978). Stone (1980) in his study of Lake Pontchartrain found that the average biomass (mostly live material) consistently ranged from 2000 to 2500 g dry wt/m² in the marshes and was composed primarily of S. patens.

Bahr and Hebrard (1976) estimated that herbivorous insects grazed approximately seven percent of the brackish marsh production in the Barataria Basin. Bahr and Hebrard (1976) also estimated 0.004 lb/ft² of primary production was ingested by muskrats annually. Palmisano (1972) found that brackish marsh composed of a mixed community Scirpus olneyi and S. patens produced the greatest muskrat density, based on house counts (Table IV-21). Brackish marsh comprised 36.2 percent of the area surveyed and contained 72.5 percent of the muskrat houses observed for a productivity index of 2.0. This index indicated that muskrats occurred in brackish marsh at twice average density of all marsh types. These furbearers are an important node in the food web by serving as prey for many reptiles, hawks and mammals. Appendix F contains a list of vertebrate species and their preferred food types found in Lake Pontchartrain and surrounding marshes during summer and winter periods (Stone 1980).

Bahr and Hebrard (1976) found that a net buildup of detritus (as peat) occurs in the brackish marsh area, indicating that a large portion of the total net production is neither exported nor used by higher trophic levels within the system.

The brackish marsh area is subject to tidal effects with a net downstream flow. However, the inland movement of water serves to determine the kinds of marsh vegetation, aids in recirculating nutrients and allows the inland migration of larval forms of estuarine species, many of which are incapable of swimming upstream. Tidal activities result in rapid physiochemical changes within a habitat. Thus resident species of brackish marsh habitat have a high tolerance to these rapid changes, and many organisms have developed physiological mechanisms allowing them to maintain stable concentrations of salts in their body tissues.

Primary production in brackish marsh water bodies is controlled by turbid conditions that limit photosynthesis (Bahr and Hebrard, 1976). During the winter, tides and tidal currents are low in amplitude, and water bodies clear up allowing the growth of several macrophytes adapted to colder conditions. During the summer, higher turbidity levels restrict primary production in the water bodies to photoplankton, except for the shallowest areas, which are colonized by an important benthic diatom community. Stone (1980) described phytoplankton, microzooplankton and macrozooplankton abundance categories for Lake Pontchartrain, its passes and surrounding marshes for the seasons of 1978.

TABLE IV-19. Estimated Net Primary Production Per Square Meter for Brackish Marsh Habitat. Total net primary production is calculated as E_1^0 (percent coverage times net primary production) for a species.

Species	Net primary production (g/m ² /yr)	Coverage ^a (%)	Contribution to total habitat net primary production (g/m ² /yr)
Saltmeadow cordgrass	4,200 ^b	36.70	1,541
Widgeon-grass	5,840 ^c	4.67	273
Saltgrass	2,900 ^b	9.88	287
Other ^d	- - -	15.81	655
Open Area	- - -	32.77	- - -
Total net primary production			2,756

^aChabreck 1972

^bGosselink et al. 1977

^cNixon and Oviatt 1973

^dProductivity assumed to be equal to the average for other species in the habitat.

Source: Gosselink et al. 1979

TABLE IV-20. Production Values ($\text{g}\cdot\text{m}^{-2}\cdot\text{yr}^{-1}$) for the Four Lake Pontchartrain Marsh Sites Using the Smalley Method with Experimental Data and the Wiegert and Evans Method with Predicted Experimental Data

Method	New Orleans			Walker Canal
	Goose Point	Irish Bayou	East	
Smalley (experimental)	2541	3192	2605	4411
Wiegert & Evans (predicted)	2087	2861	3065	3464
Wiegert & Evans (experimental)	3075	3595	3053	5509

Source: Stone, 1980

TABLE IV-21. Distribution of Selected Species of Wildlife by Marsh Types in Louisiana Coastal Marsh

Marsh ^b Type	Population Distribution (%)	Habitat Distribution (%)	Preference ^a Index
<u>Dabbling Ducks^c</u>			
Saline	1.8	13.0	0.14
Brakish	30.0	37.0	0.81
Intermediate	29.3	19.0	1.54
Fresh	38.9	31.0	1.25
<u>Muskrats^c</u>			
Saline	14.5	11.6	1.25
Brakish	72.5	36.2	2.00
Intermediate	8.7	20.3	0.43
Fresh	4.3	31.9	0.13
<u>Alligators^d</u>			
Saline	0.0	21.7	0.00
Brackish	31.9	30.6	1.04
Intermediate	33.7	16.5	2.04
Fresh	34.4	31.2	1.10

^aPreference index = $\frac{\text{Population distribution}}{\text{Habitat distribution}}$

^bBoundaries delineated by Chabreck et al. (1968)

^cData from Palmisano (1972)

^dData from McNease and Joanen (1978)

The dominant energy flow pathway for brackish marsh water bodies in the Barataria Basin goes from the emergent macrophytes to the upper trophic levels via detritus washed into the estuaries (Bahr and Hebrard 1976). Some of this detritus is presumably of fresh marsh or even swamp forest origin, and some is locally derived. Brackish marsh detritivores are basically the same as those found in the fresh marsh system, except for some insect larvae which are replaced by crustaceans not found in a freshwater marsh system. Polychaetes are prominent in brackish marsh and represent a major food item of many predacious finfish and other carnivores. Nematodes, ostracods and amphipods are also quite prominent in the brackish marsh detritivore community. Copepods are the dominant zooplankton found in brackish marsh.

Wading birds seem to have an important role among predators obtaining food from brackish marsh water bodies. These numerous birds recycle nutrients such as phosphorus obtained from feeding and then returned to wetlands by their excrement. This pathway represents a reversal of the usual net downstream flux of nutrients.

Most carnivorous fish associated with the brackish marsh belong to the nekton category. Species such as spot, Southern flounder, Croaker, Sea trout and Black and Red drum provide sport for a variety of fishing enthusiasts. This quest by sportsmen provides a link between man and the brackish marsh primary production.

4.3.2.4 Areas of Special Concern. Criteria employed in determining these areas is provided in Section 4.1.2.4. Areas within the brackish marsh which are noteworthy include:

Lost Lake - high concentrations of water fowl including geese
Lake Merchant - oyster beds

4.3.3 Social.

4.3.3.1 Land Uses. Except for oil and gas facilities and related canal features, the brackish marsh is primarily in a natural state although areas may be preferentially managed for certain species of flora and fauna. (Also see Section 4.1.3.1.)

4.3.3.2 Cultural Features. See Sections 4.1.3.2 and 4.2.3.2.

4.3.3.3 Other Programs in the Area. See Section 4.1.3.3.

4.3.4 Economics. See Sections 4.1.4 and 4.2.4.

4.4 Intermediate Marsh. Some 1,239 acres of intermediate marsh are located within the proposed and unauthorized project areas. Projects 8-2D (unauthorized) and 3-2 (unauthorized) contain most of the intermediate marsh, with 484 and 412 acres respectively. Project 8-1 (unauthorized) contains 185 acres, 136 acres are located within project 4-2B, 12 acres in project 8-2E and 10 acres in project 3-3 (Appendix A). Overall, intermediate marsh, excluding associated water bodies, comprises 56,318 acres or approximately 4.2 percent of the parish area (Wicker et al. 1980).

4.4.1 Physical.

4.4.1.1 Meteorological and Climatological. Intermediate marsh occupies a relatively narrow east to west band across the approximate center of the parish. No site specific data are known but the intermediate marsh is probably influenced most by the coastal climatic factors discussed in Section 4.1.1.5 and therefore experiences a generally drier but less extreme climate than to the north. Also see Section 4.1.1.1 for general regional climatic indexes.

4.4.1.2 Topological. No site specific information is known. See Sections 4.1.1.2, 4.2.1.2, 4.3.1.2 and 4.5.1.2.

4.4.1.3 Geological. In subsurface deposits, intermediate marsh and more specifically, meiofauna associated with intermediate marsh and open water bodies, is a geologic indicator of the maximum inland extent of marine influence on older delta deposits. Due to the narrow zone intermediate marsh occupies it is the most ephemeral of the marsh types. In most of Terrebonne Parish the intermediate zone has migrated inland during the past several decades in association with marine transgression. In the extreme western part of the parish, however, the zone has remained stable or migrated slightly seaward in response to the influence of the lower Atchafalaya River. A more complete discussion of deltaic development and associated environments is provided in Section 4.1.1.3.

4.4.1.4 Soils. Free water salinities average 4.6 ppt but can range temporarily from fresh conditions to 10 ppt (Chabreck 1972). Mean organic content of the top 30 cm of the soil is 63 percent on a dry weight basis (Chabreck 1972) which is similar to that of fresh marsh but greater than those of brackish or saline marshes. Primary production of intermediate marsh, however, is on the average greater than fresh marsh and approximately equal to brackish marsh; therefore, more organics are exported and a lower percentage of production is retained in the soil in the intermediate marsh as compared to fresh marsh (Gosselink et al. 1979). Major wetland soil types are listed and described in Section 4.1.1.4.

4.4.1.5 Hydrological. Flooding of the intermediate marsh is not as periodic as brackish or saline marshes due to the diminished influences of tides. Gosselink et al. (1979) cite this diminished frequency of flooding as a contributing factor to the lower export of organics from the intermediate marsh in comparison to the more tidally influenced marshes. Also see Section 4.1.1.5 and hydrological discussions for other wetland habitats for comparative inundation regimes.

4.4.1.6 Water Quality. Water quality is treated in a regional context in Section 4.1.1.6.

4.4.1.7 Air Quality. There are no representative air quality monitoring stations for the intermediate marsh. See Section 4.1.1.7.

4.4.2 Biological.

4.4.2.1 Flora. Species that dominate the intermediate marsh are a mix of fresh and brackish marsh plants. S. patens is dominant in terms of spatial extent (Chabreck 1972) and production (Gosselink et al. 1977).

For this and other reasons, intermediate marsh is frequently grouped with brackish marsh. What characterizes intermediate marsh is the presence or absence of minor species. Plants which normally attain their greatest abundance in the intermediate marshes of Terrebonne Parish include: Acnida cuspidata, Bacopa monnieri, Leptochloa fascicularis, Paspalum vaginatum and Pluchea camphorata (Chabreck and Condrey 1979). (Also see Sections 4.3.2 and 4.4.2.3 and Table IV-17).

4.4.2.2 Fauna. Major faunal assemblages of the intermediate marsh are similar to that of the brackish marsh (Bahr and Hebrard 1976). With respect to commercially and recreationally important species, the intermediate marsh supports high densities of waterfowl and alligators (see Section 4.4.2.3).

4.4.2.3. Ecology. Intermediate marsh lies inland from brackish marsh and occupies approximately 56,318 acres in Terrebonne Parish (Wicker et al. 1980). This marsh type receives some influence from tides, and water salinities average 4.68 ppt (range 0.34 to 9.80 ppt) (Chabreck 1972). Intermediate marsh water levels are slightly greater than in the brackish marsh. Also organic matter content (average 62.7%) is greater than brackish marsh. Vegetation in the intermediate marsh habitat is more diverse than in brackish or salt marsh and contains both halophytes and freshwater species which are used as food by a wide variety of herbivores. S. patens dominates the intermediate marsh as it does the brackish type, but to a lesser degree. Other common plants are Phragmites communis, Sagittaria falcata, and Bacopa monnieri (Table IV-17, Section 4.2.2.3).

Primary productivity of intermediate marsh has been estimated at 2,800 g/m²/yr. (Table IV-22). The intermediate marsh habitat supports a transitional community of organisms which includes both marine and freshwater forms. Intermediate marsh habitat has a vertebrate species richness almost identical to that for the brackish marsh. Intermediate marsh are preferred feeding grounds for herbivorous waterfowl including the dabbling ducks which are prized by hunters (Table IV-21, Section 4.3.2.3).

Palmisano (1972) determined intermediate marsh comprised 20.3 percent of the area surveyed and contained 8.7 percent of the muskrat houses (Table IV-21). The low productivity index for intermediate marsh indicates that this type does not meet the overall requirements of muskrats. Inadequate water levels, food supplies and cover are likely contributors to the low population levels. However, alligators prefer this marsh type, and aerial inventories by McNease and Joanen (1978) disclosed that intermediate marsh produced an alligator population with almost twice the density of other marsh types (Table IV-21).

4.4.2.4 Areas of Special Concern. Criteria employed in determining these areas is provided in Section 4.1.2.4. Areas within the intermediate marsh that may be of special concern include:

- Carencro Lake - peak concentration area of waterfowl - primarily dabbling ducks
- Lake Decade - wading bird rookeries

4.4.3 Social.

4.4.3.1 Land Uses. See Sections 4.1.3.1 and 4.3.3.1.

TABLE IV-22. Estimated Net Primary Production Per Square Meter for the Intermediate Marsh Habitat. Total net primary production calculated as the E_I^n (percent coverage times net primary production) for n species.

Species	Net primary production (g/m ² /yr)	Coverage ^a (%)	Contribution total to net primary (g/m ² /yr)
Saltmeadow cordgrass	4,200 ^b	29.92	1,257
Bulltongue	2,300 ^b	3.17	73
Common reed	2,400 ^b	3.14	75
Alligatorweed	3,140 ^c	2.72	85
Other ^d	---	34.90	1,335
Open area	---	26.35	---
Total Net Primary Production			2,825

^aChabreck, 1972

^bGosselink et al, 1977

^cBoyd, 1969

^dProductivity assumed to be equal to the average for other species in the habitat.

4.4.3.2 Cultural Features. See Sections 4.1.3.2 and 4.2.3.2.

4.4.3.3 Other Programs in the Area. See Section 4.1.3.3.

4.4.4 Economics. See Sections 4.1.4 and 4.2.4.

4.5 Freshwater Marsh. There are 2976 acres of freshwater grass marshes distributed within eight of the project areas. Most of the freshwater marsh is located within the unauthorized projects; Project 4-1 contains 1485 acres, and Project 3-2 contains 779 acres. Proposed Project 4-2B also contains a substantial amount of this habitat, with 520 acres.

Fresh shrub wetlands are frequently found within the freshwater marsh or as a transition zone between the fresh grass marshes and woody swamps. Significant areas of this sub-habitat type are found within Projects 8-1 (unauthorized) (342 acres), 4-1 (unauthorized) (154 acres), 4-2B (137 acres) and 8-2A (115 acres). Inclusive of fresh shrub wetlands, there are 3724 acres of fresh marsh habitat.

Despite losing some 126,539 acres of fresh marsh since 1955 (Wicker et al. 1980), Terrebonne Parish still contains one of the largest continuous expanses of coastal freshwater marsh in the state and the nation. At present, Terrebonne Parish contains some 179,610 acres of freshwater marsh plus an additional 8,924 acres of fresh shrub wetlands. The combined acreage of freshwater shrub and marsh wetlands constitute 14 percent of the Terrebonne Parish area.

4.5.1 Physical.

4.5.1.1 Meteorological and Climatological. Hydroclimatic variation over the study area is discussed in Section 4.1.1.5 and general climatic indices are provided in Section 4.1.1.1.

4.5.1.2 Topological. The elevation range of fresh marsh is probably the most variable of the coastal marsh types for two reasons. First, water level variability is greater due to the increasing influence of riverine and local runoff variables and marsh elevation is some function of water level. Second, flotant marshes, which are one type of freshwater marsh, have a unique ability of changing their elevation in response to water level variations. There is an unknown but definite limit to the elevation that can be obtained by the flotant marsh. For example, during the high flood years of 1973-1975, the flotant marsh was submerged and experienced considerable break-up (Chabreck 1981; Baumann and Adams 1982). In relation to upland topology, however, the elevation variability and slope of freshwater marsh must be considered slight. Also, see Section 4.1.1.2 for general topologic characteristics of Terrebonne Parish.

4.5.1.3 Geological. Extensive freshwater marshes along the Louisiana coast are in general an indicator of stable or prograding delta systems. The three largest expanses of fresh marsh in coastal Louisiana lie in the Terrebonne-St. Mary Parish area, Plaquemines Parish, and Cameron-Vermilion Parish area. The first two areas are maintained by abundant freshwater and associated sediment and nutrient supplies from the Atchafalaya and Mississippi Rivers, respectively. The Cameron-Vermilion area is somewhat artificially maintained by a series of control structures

that retard saltwater intrusion and by the input of freshwater from the Mermentau River and draining of rice fields.

Freshwater marshes were formerly extended into southeast Terrebonne Parish but they have largely been replaced by more salt tolerant marsh types and open water bodies. Throughout the past several centuries, the freshwater supply to the area has diminished as the Lafourche-Mississippi system was undergoing abandonment. The artificial damming of Bayou Lafourche in 1904 and the construction of waterways and canals through the marshes to the Gulf accelerated the loss of fresh water and the increase in saltwater intrusion. Freshwater marshes in western Terrebonne Parish have remained relatively stable and in some local areas have expanded as a result of the increase in flow transported by the Atchafalaya River (now maintained at 30 percent of the combined Mississippi and Red River 1950 flow regime), and lesser but significant inputs from the Lake Verret watershed.

Fresh flotant marshes are particularly susceptible to land loss processes as there are no brackish or saline equivalent marsh types. Therefore once significant amounts of salt water invade a fresh flotant marsh, the plants die and are not replaced. The organic mat is then highly susceptible to erosion from storms and will not recover.

The ontogeny of flotant marshes is not well understood, as they have not been the subject of much research since the descriptive efforts of Russell (1942).

A more complete discussion of the important geologic processes affecting habitat development and variability is included in Section 4.1.1.3.

4.5.1.4 Soils. Fresh marsh soils contain the highest organic content on a percent dry weight basis of all the soils associated with the various habitats. Mean organic content is 68 percent (Chabreck 1972) but can exceed 90 percent in flotant marshes. Mean free water salinities are 0.73 ppt and range from zero to 4.5 ppt (Chabreck 1972). Major wetland soil types are listed by habitat association in Table IV-5 and are described in Section 4.1.1.4.

4.5.1.5 Hydrological. Fresh marsh flooding is the most irregular and lowest in frequency of flooding of marsh habitats, a factor which accounts for the lower export of organics (Gosselink et al. 1979). Duration of flooding can be for extremely long periods of time. While duration of flood per event is normally expressed in hours for the saline marsh, flood events persist for days and often for months in the fresh marshes. Although tides are present in much of the fresh marsh area for substantial periods of time, the tide generally does not influence the periodicity or duration of flooding due to its gently diminished amplitude. True tides generally have a range of a few inches or less on the fresh marsh.

Also see Section 4.1.1.5 and hydrologic discussions for other wetland habitats, for comparative inundation regimes.

4.5.1.6 Water Quality. Water quality is treated in a regional context in Section 4.1.1.6.

4.5.1.7 Air Quality. There are no representative air quality monitoring stations for the freshwater marsh. See Section 4.1.1.7.

4.5.2 Biological.

4.5.2.1 Flora. Fresh marsh contains the highest diversity of the marsh habitats (Bahr and Hebrard 1976). Species dominance can change seasonally, as the fresh marsh contains a large number of annuals in addition to perennials. A typical assemblage includes: Panicum hemitomon, Eichhornia crassipes, Pontederia cordata, Alternanthera philoxeroides, Hydrocotyle sp., Sagittaria sp., Eleocharis sp., as well as a number of annuals. According to Kinler et al. (1981) the climax species of floatant marsh is Panicum hemitomon. A more complete listing of the species found in the fresh marsh of Terrebonne Parish and their relative abundance are included in Section 4.2.2.3 and species that are important food sources for wildlife are included in Appendix E.

4.5.2.2 Fauna. Consumers are discussed in Section 4.5.2.3. A listing of fauna is provided in Appendix F.

4.5.2.3 Ecology. Fresh marsh occupies the zone inland from the intermediate marsh and south of the Prairie formation and Mississippi River Alluvial Plain. In many areas fresh marsh is intermixed with swamp. Wicker et al. (1980) estimated that the fresh marsh type encompassed 188,534 acres in Terrebonne Parish. Water levels in Louisiana freshwater marshes are controlled more by upstream flows, rainfall, and the direction of prevailing winds than by tidal effects. Water salinities in Terrebonne fresh marsh areas average 0.73 ppt (range: .09-4.54) (Chabreck 1972). Concentrations of dissolved oxygen, particulate and dissolved carbon, dissolved heavy metals, nitrate, and ammonia, along with other chemical and physical parameters of the water and sediments, change dramatically as salinities increase from 0.1 ppt to 1.0 ppt (Morris et al. 1978). Organic content (mean: 67.6%) is greatest in the fresh marsh substrate due to the low frequency of inundation (marsh flushing) which allows much of the organic production to accumulate in place. Gosselink et al. (1977) showed that as the frequency of inundation of coastal marshes decreases, the inorganic concentration increases; that is, flooding frequency is directly related to inorganic silt input and to organic export.

In some fresh marshes, soil organic matter content exceeds 80 percent and the substrate for plant growth is a floating organic mat, referred to as floatant by Russell (1942). Fresh marsh supports the greatest diversity of plants and contains many preferred foods of wildlife (Table 17-32 and Appendix E). This increased plant diversity is due, in part, to the presence of annuals. Brackish and salt marsh habitats are dominated by perennials, which form stable plant communities that change relatively little from year to year. In contrast, fresh marshes support a large number of annual grasses. The seed of some of these germinate in the spring and others in the fall. The dominant annual at a single location, therefore, often changes from season to season and from year to year depending on the degree of competition from perennials and on marsh levels during germination periods. An estimate of net primary production for fresh marshes in Louisiana based on the measured productivity of selected plants is 2,200 g/m²/yr. (Table IV-23). Dominant plants include Panicum hemitomon, Eleocharis sp., Sagittaria falcata, and Hydrocotyle umbellata.

TABLE IV-23. Estimated Net Primary Production Per Square Meter for the Fresh Marsh Habitat. Total net primary production is calculated as the E_1^n (percent coverage times net primary production) for n species.

Species	Net primary production (g/m ² /yr)	Coverage ^a (%)	Contribution total to net primary (g/m ² /yr)
Bulltongue	2,300 ^b	17.90	412
Alligatorweed	3,140 ^c	4.19	131
Saltmeadow cordgrass	4,200 ^b	7.21	302
Black rush	3,300 ^b	1.31	43
Other	---		1,344
Open	---	23.08	---
Total Net Primary Production			2,232

^aChabreck, 1972

^bGosselink et al, 1977

^cBoyd, 1969

^dProductivity assumed to be equal to the average for other species in the habitat.

The three major groups of autotrophs in fresh marsh, like other marsh types, are standing vegetation, epiphytes, and benthic algae. During the winter months benthic algae increases in significance as standing vegetation dies back, allowing more light to reach the sediment. In some cases epiphytes produce more organic carbon than their host plants (Bahr and Hebrard 1976). Net estimated annual production for freshwater marsh in the Barataria Basin is 0.22 lb carbon/ft².

Production in freshwater marshland is seasonal in nature with peak growth occurring during May and early June, when nutrients are in abundance from the decomposition of the previous year's crop, sunlight is most direct, and the photo-period is maximal. Stone *et al.* (1978) illustrated a conceptual model which presents the major components, processes and forcing functions of a Louisiana freshwater marsh (Appendix H, all appendices were published only in the Draft EIS and may be secured from the New Orleans District). Nutrients in waters flooding the freshwater marshes decrease sharply in the spring during peak growth, presumably because of uptake by plants. Nutrient concentrations in aquatic vegetation have been shown to decrease as the growing season progresses (Boyd and Blackburn 1970). This decrease is more than just dilution with the maturing tissues; it includes an actual loss from the plants to the surrounding freewater by secretion (Boyd and Blackburn 1970; Wetzel 1969). Some species may be nutrient conservative and translocate some of the nutrients back into the underground storage organs between growing seasons, while others act as nutrient pumps and sacrifice nutrients in the above-ground tissue (Klopatek 1975, 1978; Prentki *et al.* 1978). Only in the case of large trees can the nutrient storage capacity be considered permanent. Bahr and Hebrard (1976) estimated the above-ground biomass for fresh marsh in the Barataria Basin at approximately 8,000 lb. per acre.

Since freshwater marsh is generally free of tidal flushing, rainfall provides most of the flushing action. Occasionally prolonged southeasterly winds back up water in the entire wetland system until the marsh is covered.

Water movement seems to stimulate marsh production, and growth of emergent vegetation is greater at the edge of waterbodies than farther inland. Water movements in fresh marshland are dependent on gradients and the speed with which coastal wetlands drain off excess water to their downstream marsh unit (Bahr and Hebrard 1976).

Insects are probably the most important group of grazers in the fresh marsh, ingesting approximately five to 10 percent of the net plant production. In a bulltongue community in southeastern Louisiana, Louton and Bouchard (1976) identified 40 insect taxa. It is unfortunate that little is known about the fresh marsh insect community.

Nutria are the most significant and abundant large herbivores in the fresh marsh system. Deer also graze in fresh marsh and are estimated to occur at a density of one animal per 142 acres. Fresh marsh supports approximately one rabbit per acre, but these animals are mostly concentrated on the elevated areas and do not contribute significantly to grazing marsh vegetation.

Detritivores in the fresh marsh wetland include small crustacea (amphipods and mysids), which shred detritus fragments. These detritivores are concentrated at the water and marsh interface. Dead plant tissue is transformed into high quality complex protein by overwinter bacterial action which converts detrital carbon to bacterial carbon and provides an increased nutritional value to detritivores and higher forms of heterotrophs. Hood and Myers (1976) isolated more bacterial types from fresh marshes than from saline ones.

Four possible fates await the organic carbon produced within this system: (1) deposited as incompletely decomposed detritus (peat); (2) enters detritivore cycle; (3) grazed by herbivores and ultimately turned into carnivore flesh; and (4) exported by currents in waterbodies draining the marsh. The annual export data on nutrients (Gosselink and Turner 1978) clearly indicate that the fresh waters in the upper Barataria Basin are rich in N and P. Some of these nutrients are thought to be derived primarily from terrestrial sources such as agriculture and urban runoff. Nutrients from these waters are taken up by plants and incorporated into detritus. Export of these materials represents an important source of raw materials to the lower estuary. The major pulse of these materials coincides with the time of high detrital formation and arrival of migrant species which enter the estuarine area for growth and spawning purposes.

Predator insects and spiders, reptiles and amphibians, insectivorous and raptorial birds and predatory mammals compose the higher trophic level.

Practically nothing is known about either herbivorous or carnivorous (or parasitic) insects in marshes, although the density of biting flies and mosquitoes in some marsh areas makes them very important to man.

Water bodies within a fresh marsh system act as conduits transporting material to more downstream areas (Bahr and Hebrard 1976). Primary production in fresh marsh bayous is overshadowed by a high concentration of organic material exported from the wetland proper. A high-energy hydrologic regime will carry much of the production out of the marsh (Mason and Bryant 1975), but there are at least two feedback loops that modify this response. Vegetation of the marsh acts as a silt trap, particularly at the edge (Buttery *et al.* 1965), which tends to increase the sedimentation rate and raise the elevation of the marsh. As the marsh elevation increases, the frequency and depth of flooding decrease so that less organic production is exported and is instead deposited as peat. This deposition results in further increases in marsh elevation. These two factors result in continued growth upward until peat accumulations alter hydrology by acting as barriers to percolation of surface waters (Gosselink and Turner 1978).

Another feedback loop through the biota occurs with nutrients. The increase in elevation and total standing biomass aboveground and peat underground tend to close the nutrient cycle, and less flux of nutrients occurs across marsh boundaries (Gosselink and Turner 1978).

Diversity and production of aquatic plants are partially controlled by both turbidity and flow rate. Hydrologic regime can contribute to elevational and substrate differences which are a chief source of species diversity in wetlands (Hinde, 1954).

The greater the spatial heterogeneity, the greater the number of niches and the more opportunity for a successful invasion by a species (Jacobs 1975). Species diversity of phytoplankton is greater in bayous and ponds in swamp and fresh marshes than in other wetland types.

Herbivores and detritivores occurring in fresh marsh include zooplankton, some nektonic forms, benthic animals including meiofauna, crustacea (grass shrimp) and waterfowl.

Bahr and Hebrard (1976) described Barataria Basin zooplankton as consisting of water fleas, typical freshwater crustacea, rotifers and copepods. Little is known about the benthic fauna in fresh marshes. Freshwater shrimp and crawfish are sometimes included in the benthic community. Herbivorous nekton important in the freshwater marshes include carp, sheepshead minnow and the wide-ranging menhaden.

The uppermost trophic levels in fresh marsh waterbodies include catfish, bowfin, bluegill, gar, crappie, bass, water snakes and some occasional marine migrants.

Wading birds such as egrets remove large quantities of primary consumers.

4.5.2.4 Areas of Special Concern. Criteria employed in determining these areas is provided in Section 4.1.2.4.

The entire freshwater marsh area could be regarded as an area of special concern due to its susceptibility to land loss (4.5.1.3) and its proximity to developed areas. The fresh marsh of Terrebonne Parish traditionally produces high yields of nutria fur, and large numbers of white-tailed deer utilize spoil banks and natural topographic highs within this freshmarsh zone (Bodin 1982). The fresh marsh also provides a feeding ground for the endangered Southern Bald Eagle particularly along the freshmarsh-swamp or freshmarsh-ridge interface area (see Section 4.6.2.4). Other more specific locations within the fresh marsh that are of particular biologic importance include:

Bayou Penchant and Turtle Bayou areas--high concentrations of the
American alligator

Lake Decade, Lake Penchant, Lake Hatch,

Palmetto Bayou and Kent Bayou areas--wading bird rookeries

Bayou Penchant-Carencro Bayou areas--waterfowl concentrations

4.5.3 Social

4.5.3.1 Land Uses. Fresh marshes remain primarily in a natural state although areas may be preferentially managed for certain species through such practices as marsh burning. Numerous oil and gas canals and other associated development features are dispersed throughout the fresh marsh. Fresh marshes that fringe natural levee areas are subject to greater pressure for other use development. A minimum of 1,798 acres of fresh marsh, particularly, have been drained primarily for domestic animal grazing purposes (Wicker et al. 1980). Late nineteenth century and early twentieth century attempts at converting fresh marsh to agricultural lands have largely been failures, with these areas either becoming open water bodies as a result of oxidation of the organic marshes resulting in

subsidence, or returning to one or more of the marsh habitats. Also see Section 4.1.3.1.

4.5.3.2 Cultural Features. See Section 4.1.3.2.

4.5.3.3 Other Programs in the Area. See Section 4.1.3.3.

4.5.4 Economics. See Sections 4.1.4 and 4.2.4.

4.6 Cypress-Tupelogum Swamp. There are 2,014 acres of swamp distributed within 18 of the project areas. Proposed project 1-1B contains the largest expanse of this habitat with 547 acres. Other projects that contain considerable areas of swamp include: 4-1 (unauthorized) with 494 acres; 4-2B with 326 acres; and 8-2D (unauthorized) with 136 acres. Within Terrebonne Parish there are 94,225 acres of this swamp type which represents 7.0 percent of the total parish land and water area (Wicker et al. 1980).

4.6.1 Physical

4.6.1.1 Meteorological and Climatological. A general discussion of climate is provided in Section 4.1.1.1. Section 4.1.1.5 provides further discussion on the hydroclimate of the area as well as intraregional variations in climate.

4.6.1.2 Topological. The swamp forest is the lowest in elevation of the non-marsh habitats. Cypress swamps can exist on landscapes well below local mean water level as evidenced by inundation time (Section 4.6.1.5). As elevation increases and inundation time decreases, the swamp forest transcends into bottomland hardwood forests. Also see Sections 4.1.1.2, 4.2.1.2, 4.3.1.2 and 4.5.1.2.

4.6.1.3 Geological. Swamp forests in Terrebonne Parish occupy interdistributary basins up to the base of the natural levees. Along several of the smaller distributaries and other lower levees the swamp forest can occupy the levee area. Swamp forest represents the lower energy environments of active distributary systems and are consequently dominated by fine-grained deposits. Cypress-tupelogum is a climax stage but will revert to hardwoods if inundation is reduced. Hardwoods do not appear to be a necessary predecessor to cypress-tupelogum. Cypress-tupelo has been found to invade marsh communities (Penfound 1952) and Willow (Salix sp. communities (Penfound and Hathaway 1939) in south Louisiana.

4.6.1.4 Soils. Free water soil salinities are at or very close to zero. Tupelogum cannot withstand saltwater although cypress has been found to be growing in areas where saltwater attained a maximum of 8.9 ppt (Penfound and Hathaway 1938). Major wetland soil types are listed by habitat association in Table IV-5 and are described in Section 4.1.1.4.

4.6.1.5 Hydrological. Inundation frequency of the cypress-tupelogum swamp is low because the swamp remains flooded for extended periods of time. In a deep swamp near Thibodaux, flood events averaged 9.8 per yr but the swamp remained flooded 88 percent of the time (Baumann 1980). Tidal effects on water level in the swamps is normally negligible. Water level variability is a function of river levels, local rainfall surplus conditions and seasonal gulf cycles which have a backwater effect.

In the same swamps Conner *et al.* (1981) noted a decrease in recruitment in recent years despite widespread seedling germination. Apparently, the drying period is not sufficiently long enough to permit the seedlings to grow above flood levels. It is not known whether this phenomenon indicates that recruitment of cypress in the deep swamp only occurs during episodic long drought periods (which would also help to explain the even age classes of trees), or whether subsidence has increased the level of flooding and decreased the probability of future cypress recruitment.

4.6.1.6 Water Quality. Water quality is treated in a regional context in Section 4.1.1.6.

4.6.1.7 Air Quality. There are no representative air quality monitoring stations for the cypress-tupelogum swamp. See Section 4.1.1.7.

4.6.2 Biological.

4.6.2.1 Flora. See Section 4.6.2.3.

4.6.2.2 Fauna. See Section 4.6.2.3.

4.6.2.3 Ecology. This habitat type is typically located inland from fresh marsh areas. Meyer and Hendrickson (1919) defined bald cypress-tupelo swamps as "the lowest lying and most recently formed areas of alluvial soil". The bald cypress-tupelogum swamps are unique in that plant species in these habitats are able to tolerate saturated soils and extended flooding. Drainage and elevation are important factors in determining plant communities. The extent and duration of flooding generally determines the species composition. Zeringue (1980) in his study of the Lac Des Allemands Basin determined frequency and density of tree species and woody understory species for swamp, bottomland hardwoods and spoil banks (Appendix E). He also determined frequency of occurrence of herbaceous vegetation for swamp, bottomland hardwood, spoil bank, and marsh habitat types (Appendix E). The four dominant species in the overstory were Nyssa aquatica, Taxodium distichum, Acer rubrum var. drummondii, and Fraxinus pennsylvanica.

Soil in the swamp forest (e.g. Mississippi River sediment) is composed largely of clay (38 percent), which is extremely fine and therefore has more surface area than soils composed of coarser particles, (Section 4.1.1.4). Swamp soils in the Lac Des Allemands area were found to have a concentration of some heavy metals (Bahr and Hebrard 1976).

Decomposition of detritus releases inorganic nutrients that are required for primary production. These nutrients accumulate in soils and are used by future generations of plants. Nutrient turnover rate is high and nutrients are used up shortly after being released to the soil. Decomposition is rapid, resulting in little or no buildup of organic matter on the forest floor. Soil chemistry is closely related to the flooding regime, which affects the decomposition rate of detritus and the inorganic oxidation-reduction reactions (Bahr and Hebrard 1976).

Autotrophs and Primary Production

Trees dominate total plant biomass, occupy the upper level of growth, and filter out most of the sunlight to the understory. A major portion

of tree biomass is composed of woody structural material that does not photosynthesize. Mean standing biomass of all autotrophs in the wetland portion of the Lac Des Allemands swamp forest has been estimated to average about 3.5 lb/ft², of which trees make up the major portion (Bahr and Hebrard 1976). Conner and Day (1976) also reported a total production of 1140 g wt/m²/yr for a Lac Des Allemands cypress-tupelo swamp.

Primary Production and Primary Consumption

Average annual productivity of the Lac Des Allemands swamp forest system was estimated at 0.20 lb/ft² (Bahr and Hebrard 1976). Two major energy pathways are used for the distribution of organic carbon: (a) grazing of living plant material by herbivores, and (b) ingestion of dead plant matter (detritus) by detritivores. Twice as much energy from the Lac Des Allemands swamp enters the food web via litterfall as is grazed directly. Litterfall occurs in pulses rather than evenly through the year (Figure IV-28). Table IV-24 provides productivity values for a St. Charles swamp. Leaf litter from a cypress-tupelo swamp in the Atchafalaya Basin was analyzed for various nutrients (Table IV-25).

The forest tent caterpillar (Malacosom disstria) is a crude but important herbivore. These animals have been estimated at densities up to 365 animals per m². At times these caterpillars are responsible for severe defoliation of the swamp forest. (Bahr and Hebrard 1976; Stone 1980).

The tent caterpillar provides a vehicle by which plant carbon from the tree canopy is transported to the forest floor. This transport of plant carbon to the forest floor is important during spring when very little litterfall occurs.

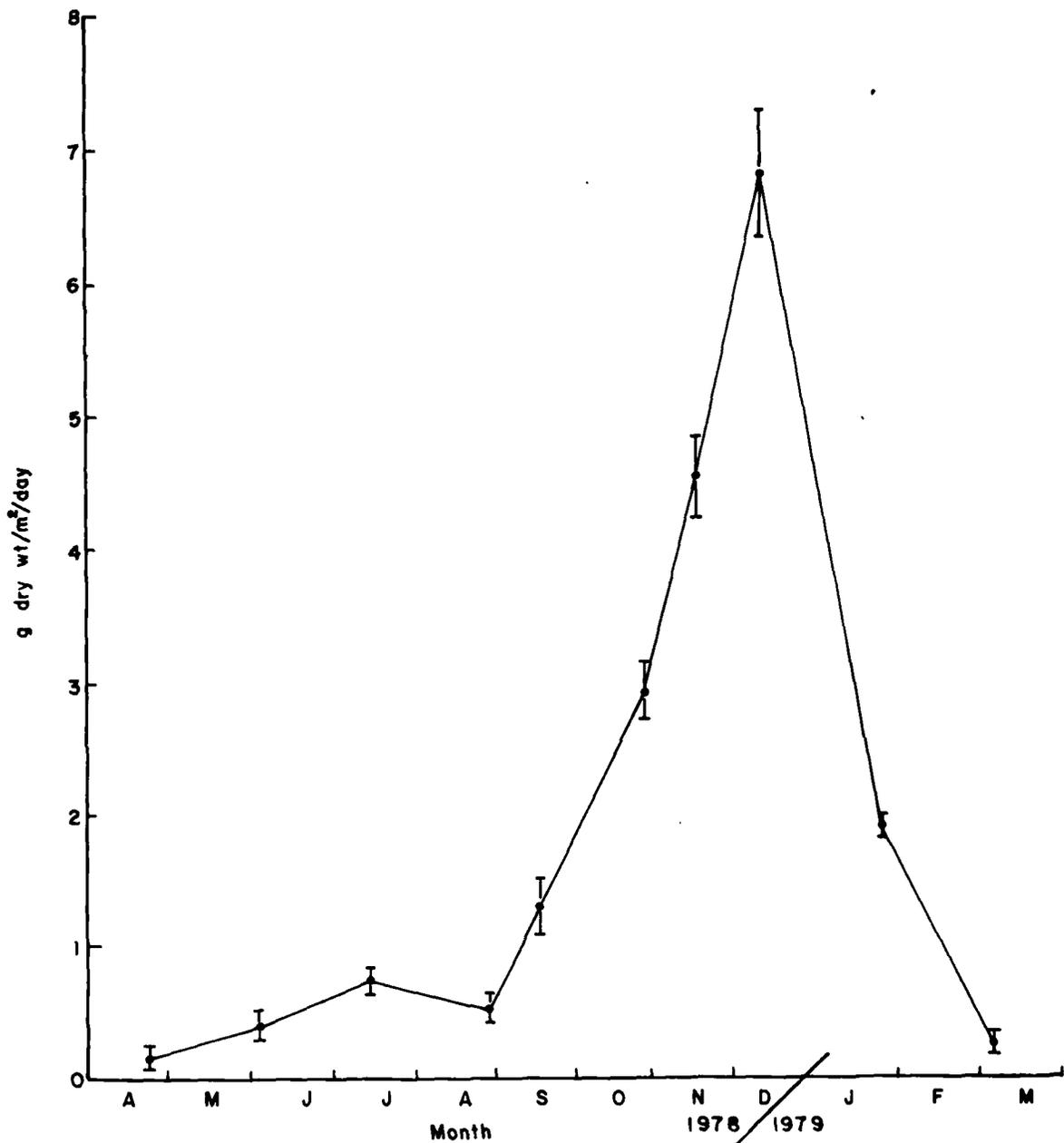
Other herbivores include deer which may occur in densities of up to one per 30 acres; rabbits, up to one per three acres; squirrels up to one per four acres; and also many small rodents and seed-eating birds.

Detritivores are of extreme importance to the swamp forest and consist of a variety of organisms including insects, crustacea, microbiota, and fungi. Their intensity is revealed by a lack of detritus buildup on the forest floor.

Crawfish are one of the more important macroscopic detritivores. These animals mechanically shred leaves on the forest floor, increasing leaf surface area resulting in further decomposition by the microbial community (Bahr and Hebrard 1976). Amphipods and aquatic insect larvae are also important in the fragmentation process.

"The utilization of detritus energy seems to consist of a cycle of ingestion by detritivores followed by egestion of unassimilated cellulose material, which is then attacked by bacteria. The particles are enriched by the bacteria converting cellulose into animal protein, available in turn to higher trophic levels via predation" (Bahr and Hebrard 1976).

Swamp forest floor sediments contain cellulose-decomposing bacteria which are critical in the decomposition process of woody material.



TERREBONNE PARISH-WIDE FORCED DRAINAGE ENVIRONMENTAL IMPACT STATEMENT	
LITTER-FALL IN A ST. CHARLES SWAMP SITE	
T. BAKER SMITH & SON, INC. CIVIL & CONSULTING ENGINEERS, LAND SURVEYORS & ENVIRONMENTAL RESEARCH HOUMA, LOUISIANA	U.S. ARMY ENGINEER DISTRICT NEW ORLEANS CORPS OF ENGINEERS NEW ORLEANS, LOUISIANA
FIGURE IV-28	

TABLE IV-24. Litter-fall and Productivity Values for a St. Charles Parish
Swamp Site

Biomass ^a g dry wt/m ²	27,800
Litter-fall/day g dry wt/m ² /day	1.7
Total litter-fall g dry wt/m ² /yr	567
Stem biomass production g dry wt/m ² /yr ^a	530
Net primary productivity g dry wt/m ² /yr ^b	1097

a Estimated from transect data

b Sum of total litter-fall and stem biomass production Stone, 1980

TABLE IV-25. Chemical Analysis of Leaf Litter Collected in a Cypress-Tupelo Swamp

Collection period	Total Litter-Fall (grams)	N	P	K	Ca	Mg
Nov. 15 - Dec. 15	364.5	5.22	0.38	1.16	5.38	0.60
Dec. 15 - Jan. 15	99.4	1.57	0.11	0.09	1.05	0.08
Jan. 15 - Feb. 15	47.7	0.50	0.02	0.03	0.56	0.03
Feb. 15 - Mar. 15	45.8	0.71	0.06	0.17	0.60	0.05
Mar. 15 - Apr. 15	191.6	4.19	0.39	1.80	1.90	0.30

Carnivores in the wetland portion of the swamp forest system include spiders, voracious insects (dragon flies), reptiles (snapping turtles, snakes, and alligators), mammals (bats, shrews, minks, nutria, otters, raccoons, opossums and bobcats), insectivorous birds and raptorial birds (Appendix F). Nine active and two inactive wading bird colonies were surveyed in the Lac Des Allemands Basin (Zeringue 1980). These colonies contained an estimated 41,000 pairs of wading birds. Little Blue Heron, Cattle Egret and Snowy Egret were the common species. Reptiles and amphibians are represented by more species in the swamp forest than in any other wetland sub-unit. Table IV-26 lists occurrence of herpetofauna in a cypress-tupelo swamp in the Atchafalaya Basin.

Swamp Forest Associated Water Bodies

The constantly flooded portion of the swamp forest system consists mostly of bayous which are generally sluggish, turbid, eutrophic systems. These sluggish waterways seem to serve as conduits transporting detritus particles, organic decomposition products, and inorganic nutrients which have been deposited from excess water flowing slowly over the swamp forest floor into the bayous.

Primary Production

Primary production in the bayous is the result of (1) rooted aquatic plants such as coontail and fanwort; (2) floating and emergent aquatics; and (3) phytoplankton (Bahr and Hebrard 1976). Due to the lack of available sunlight, waterbodies in the swamp forest system are heterotrophic, with total consumption exceeding total production.

The higher trophic levels within waterbodies are supported primarily by an estimated annual detritus export of 0.04 lb organic matter per ft² of wetland (Bahr and Hebrard 1976). The excess production washed off the swamp forest floor into the waterbodies is also exported from the swamp area to southern habitats.

Day *et al.* (1976) calculated that approximately 9,900 tons of organic matter, 940 tons of nitrogen and 140 tons of phosphorus are exported annually from the Lac Des Allemands swamp to the lower Barataria Basin.

Primary Consumption

The most important primary consumers in the swamp waterbodies include crustacea (amphipods, grass shrimp and crawfish), flat worms and segmented worms, insect larvae, mollusks, finfish and the microbial community (Bahr and Hebrard 1976).

Predation

The upper trophic levels in swamp forest waterbodies include insect larvae (midges), zooplankton (rotifers and waterfleas) and nekton (actively swimming shellfish and finfish). One of the prominent carnivores in the swamp forest waterbodies is the catfish (Bahr and Hebrard 1976). The catfish has been estimated to occur at a density of up to 150 fish per acre of waterbody. Ictalurus spp. and Ictiobus spp. were the most important commercial taxa of an annual Lac Des Allemands commercial fish harvest of approximately 1,466,000 kilograms

TABLE IV-26 . Herpetofauna Known to Occur in an Atchafalaya Basin Cypress-Tupelo Swamp

Salamanders

Amphiuma tridactylum
Desmognathus sp.
Eurycea quadridigitata
Notophthalmus viridescens
Siren intermedia

Frogs

Acris crepitans
Bufo vallicipes
Bufo woodhousei
Gastrophryne carolinensis
Hyla cinerea
Hyla crucifer
Hyla squirella
Hyla versicolor Complex
Pseudacris triseriata
Rana catesbeiana
Rana clamitans
Rana grylio
Rana sphenoccephala

Lizards

Anolis carolinensis
Eumeces fasciatus
Eumeces laticeps
Scincella laterale

Snakes

Agkistrodon contortrix
Agkistrodon piscivorus
Coluber constrictor
Crotalus horridus
Elaphe obsoleta
Farancia abacura
Heterodon platyrhinos
Lampropeltis getulus
Natrix cyclopion
Natrix erythrogaster
Natrix fasciata
Natrix rhombifera
Opheodrys aestivus
Regina grahmi
Regina rigida
Thamnophis proximus

TABLE IV-26.(continued)

Turtles

Chelydra serpentina
Chrysemys floridana Complex
Chrysemys picta
Deirochelys reticularia
Graptemys pseudogeographica
Kinosternon subrubrum
Macrolemys temmincki
Sternotherus carinatus
Sternotherus odoratus
Trionyx spiniferus
Graptemys kohni

Crocodylian

Alligator mississippiensis

Source: U. S. Dept. of the Interior, 1976.

(Zeringue 1980). Amphibians (frogs), swimming reptiles (water snakes, cottonmouth moccasins, turtles and alligators) and swimming mammals (otters and minks) obtain some of their food from the swamp waterbodies. Diving birds (kingfishers) and wading birds (herons and egrets) often feed along swamp bayous.

4.6.2.4 Areas of Special Concern. Criteria employed in determining these areas is provided in Section 4.1.2.4.

There are four confirmed active bald eagle nests in the Terrebonne Parish area (Burke and Associates 1976). Nesting occurs in either large cypress or oak trees. One site, near Greenwood, is within one mile of a proposed construction zone.

Swamps and bottomland hardwood forests are prime habitat for the now rare Black Bear. One sighting was reported in a swamp-bottomland hardwood forest area near Houma (Burke and Associates 1976).

Swamp loosestrife (Decodon verticellatus) is a rare Louisiana shrub found in the transition zone between swamp and marsh north of Houma (Burke and Associates 1976) although it is more abundant elsewhere.

There are a number of native orchids found in the swamp and bottomland hardwood forests of Louisiana that may exist in the area. A listing with locations of known specimens has been completed by Pridgeon and Urbatsch (1977).

4.6.3 Social.

4.6.3.1 Land Uses. In addition to trapping, fishing, hunting and passive uses of the swamp, cypress has been logged extensively. The second-growth is presently approximately 60 years or more in age over much of the area, and we may be presently at the beginning of a second cypress boom. Also see Section 4.1.3.1.

4.6.3.2 Cultural Features. See Section 4.1.3.2.

4.6.3.3 Other Programs in the Area. See Section 4.1.3.3.

4.6.4 Economics. See Section 4.1.4.

4.7 Wet Bottomland Hardwood Forest. There are 5,847 acres of wet bottomland hardwood forest distributed within 22 of the project areas. Projects containing 500 or more acres as proposed include: 1-1B (1,651 acres); 1-1A (688 acres); 2-1B (610 acres); and 6-1B (533 acres). As of 1978 only 20,343 acres of bottomland hardwood forests remained in the parish (Wicker *et al.* 1980), and 28.7 percent of those hardwoods lie within the proposed and unauthorized project areas. It is believed that all of the bottomland hardwoods that remain are wet bottomlands.

4.7.1 Physical.

4.7.1.1 Meteorological and Climatological. A general discussion of climate is provided in Section 4.1.1.1. Section 4.1.1.5 provides further discussion on the hydroclimate of the area as well as intraregional variations in climatic variables.

4.7.1.2 Topological. Bottomland hardwood forests occupy the higher elevations of the Mississippi deltaic plain. Bottomland hardwoods generally transcend into cypress-tupelogum swamps as elevation decreases, although at the distal ends of subaerial levees and along the smaller low levees (e.g. Marmande Ridge), bottomland hardwoods contrascend to marsh. Also see Section 4.1.1.2.

4.7.1.3 Geological. Bottomland hardwoods in Terrebonne Parish are confined to the natural levee areas of ancestral distributary courses of the Mississippi River. Inter-levee basins do not generally support bottomland hardwoods, as elevations relative to local water levels are too low. See section 4.1.1.3 for more details on levee development and age.

4.7.1.4 Soils. The largest number of soil types are associated with this habitat. Major soil series include the Baldwin, Commerce, Cypremort and Mhoon. These grade into the soil types of the Sharkey-swamp association. Properties of the soil types are described in Section 4.1.1.4 and are listed by habitat association in Table IV-5.

4.7.1.5 Hydrological. Flooding of bottomland hardwoods is a seasonal phenomena associated with spring floods. The magnitude and duration of the flood determines the length and depth of flooding. During low flood years much of the hardwood zone can remain flood free whereas during high floods, inundation can go uninterrupted for a few months.

4.7.1.6 Water Quality. Water quality is treated in a regional context in Section 4.1.1.6.

4.7.1.7 Air Quality. There are no representative air quality monitoring stations for the wet bottomland hardwood forest.

4.7.2 Biological.

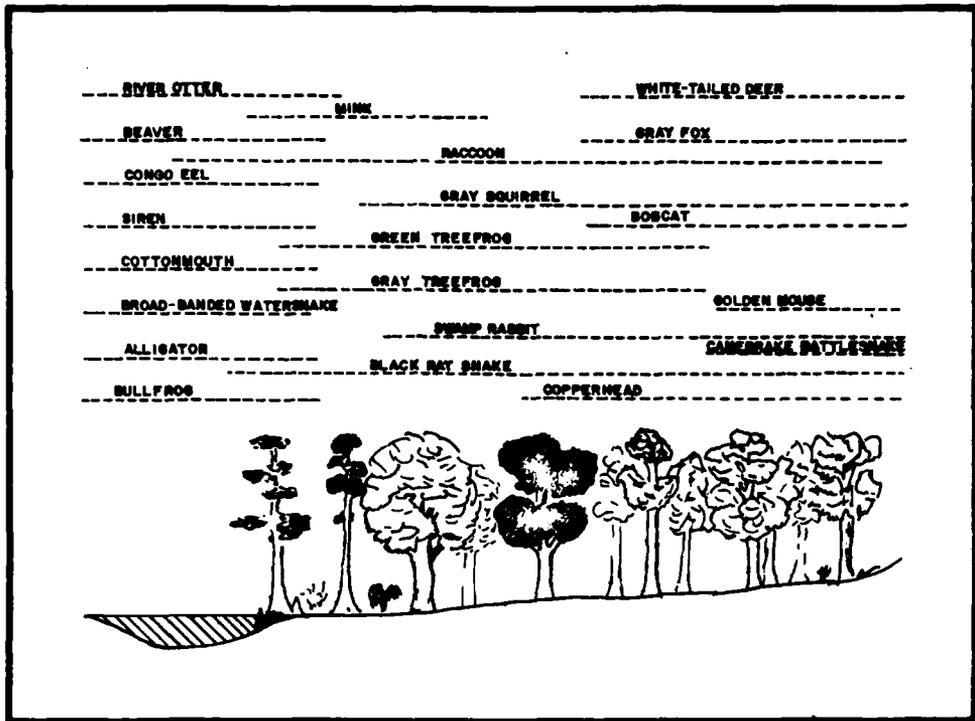
4.7.2.1 Flora. See Section 4.7.2.3.

4.7.2.2 Fauna. See Section 4.7.2.3.

4.7.2.3 Ecology. Bottomland hardwoods are located along the finger-like network of abandoned Mississippi River distributary ridges which extend through Terrebonne Parish toward the coast. Wicker et al. (1980) describe Terrebonne Parish as containing approximately 20,343 acres of bottomland hardwoods. Portions of these forests are seasonally flooded, and this constitutes palustrine forested wetlands (Cowardin et al. 1979).

Lowland hardwood wetlands have some typical geomorphological patterns that have important impacts on the distribution of vegetation and indirectly on animal abundance and distribution (Frederickson 1979) (Figure IV-29). Plant composition changes in a definite pattern along a continuum from the lowest to the highest sites.

Zeringue (1980) in an ecological characterization of the Lake Des Allemands basin, which is similar to the project area, determined the four dominant bottomland hardwood tree species were Ulmus americana, Liquidambar styraciflua, Celtis laevigata and Acer rubrum var. drummondii. The most abundant woody understory species were A. rubrum var. drummondii, Sambucus canadensis and Sabal minor. Tree reproduction made up



**TERREBONNE PARISH-WIDE FORCED DRAINAGE
ENVIRONMENTAL IMPACT STATEMENT**

**DISTRIBUTIONS OF AMPHIBIANS, REPTILES AND
MAMMALS IN LOWLAND HARDWOOD WETLANDS**

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SOURCE: FREDRICKSON, 1978.

FIGURE IV-29

approximately 50 percent of the woody understory. The more common herbaceous understory species were Rubus spp., Rhus radicans, and Saururus cernuus.

The four dominant tree species on canal spoil banks were Salix nigra, A. rubrum var. drummondii, F. pennsylvanica, and N. aquatica. The most abundant woody understory species were S. canadensis, A. rubrum var. drummondii, Cornus drummondii, and Itea virginica. The more common herbaceous understory species were Rubus spp., S. canadensis, Boehmeria cylindrica and Ampelopsis arborea.

The differences in diversity and composition of the forest are controlled in part by the varying frequency, duration, and depth of flooding and shifts in soil texture and layering as a result of floods (Lindsey et al. 1961; Bedinger 1978). Flood frequency and duration may be most important in determining plant species distribution in lowland forests because of the irregular horizontal and vertical distribution of alluvial soils (Bedinger 1978).

Not only are plant establishment and growth controlled largely by water, but aquatic and semi-aquatic invertebrate foods that are abundant during and immediately after flooding are also influenced by water level changes. Pulsations within the system make food supplies readily available for a diversity of animals.

Dominant invertebrates found in a North Carolina green ash, American elm and oak hardwood forest included six species of "red" lumbricid worms, four species of "white" enchytraeid worms, three turbellarian flatworms and several roundworms (Sniffen 1980). Isopod crustacea lead the biomass (1,114 mg dry wt/m²). Copepods and ostracods were numerous (5,829/m²). Also abundant were midge fly larvae (5,008/m²), amphipods (1,466/m²), water mites (2,063/m²) and Collembola (1,882/m²).

Mites (Acari) were the most abundant animals (48 percent in fall and 77 percent in winter) (Grey 1973) of the litter fauna. Springtails (Collembola) were second, with the flood-tolerant family Sminthuridae dominant. Earthworms are an abundant and important floodplain form and feed salamanders, shrews and a host of animals. Table IV-27 provides a listing of benthic organisms found in a Louisiana backwater area.

Predators on the invertebrates besides salamanders and shrews include mesostigmatid mites, wolf spiders, carabid beetles and various frogs. Top predators include the barred owl, rat snake and raccoon.

Zeringue (1980) found an average of 1,940 birds/km², representing 39 species, in a bottomland hardwood habitat within the Lac Des Allemands Basin. The most observed species was the Yellow-rumped Warbler followed by the American Robin, White-Throated Sparrow and Red-Winged Blackbird.

Dickson (1978) conducted a year-round census to determine bird populations within a south central Louisiana bottomland hardwood forest. Some 66 species of birds representing 27 families were censused. Highest populations (1,235 - 2,035/m²) were found December-February. Lowest numbers were detected for August-October (296-346/km²). Zeringue (1980) also studied a bottomland hardwood spoil bank and found 1,610 birds/km² representing 26 species. The most common species observed in order of occurrence were the Swamp Sparrow, Common Yellowthroat, Red-Winged

TABLE IV-27. Numerical Standing Crop of Benthic Organisms from Spring Bayou Backwater Area

	July 1960- June 1961	July 1961- June 1962	July 1962- June 1963	July 1963- June 1964	Mean	% of Total
Turbellaria	0.1	...	...	...	0.02	0.03
Nematoda	0.1	0.1	...	...	0.05	0.07
Hirudinea						
Glossiphoniidae	0.1	...	0.1	3.4	0.90	1.20
Oligochaeta						
Tubificidae	28.0	11.9	0.9	27.6	17.10	22.77
Lumbriculidae	...	2.0	1.0	...	0.75	1.00
Crustacea						
Asellidae	...	...	...	0.1	0.02	0.03
Gammaridae	3.7	...	0.1	...	0.95	1.26
Talitridae	5.8	2.8	0.1	...	2.88	3.83
Insecta						
Ephemeroptera						
Ephemeridae	...	0.1	0.4	...	0.12	0.16
Baetidae	0.2	...	...	...	0.05	0.07
Odonata						
Libellulidae	0.1	...	...	0.1	0.05	0.07
Tricoptera	...	0.6	...	...	0.15	0.20
Diptera						
Chironomidae	34.6	23.8	19.2	22.7	25.07	33.38
Ceratopogonidae	2.2	1.4	1.3	2.4	1.82	2.42
Chaborinae	47.7	30.0	11.0	7.5	24.05	32.02
Pelecypoda						
Sphaeriidae	2.9	...	0.1	0.1	0.78	1.04
Unionidae	...	0.6	...	...	0.15	0.20
Gastropoda						
Viviparidae	0.3	...	...	...	0.07	0.09
Physidae	0.2	...	...	...	0.05	0.07
Planorbidae	0.2	0.1	...	...	0.07	0.09
TOTAL	128.2	73.4	34.2	63.9	75.10	100.00

Source: Lance, 1970.

Blackbird, and Carolina Chickadee.

Bottomland hardwoods support a diversity of game birds. Common migratory puddle ducks such as the mallard and pintail inhabit flooded bottomland hardwoods. Wood ducks nest in wooded swamps and seasonally flooded bottomland hardwood forests. Another popular game bird, the American woodcock, also winters in bottomland hardwood habitats. The mourning dove and bobwhite quail are most often associated with agricultural fields and forest edges.

The white-tailed deer and black bear are two big game mammals which inhabit bottomland hardwood forests. At the present time the white-tailed deer is the only huntable big game mammal in the project area.

Small game mammals inhabiting bottomland hardwoods include the swamp rabbit, eastern cottontail, gray squirrel, fox squirrel, raccoon and Virginia opossum. The Eastern cottontail is most frequently found along interfaces of pastures and bottomland hardwood forests.

Other important food chains are based on grazing or eating the plant products: acorns feed bluejays, grackles, woodpeckers, ducks, raccoons, various mice, squirrels and deer. Rodents and box turtles graze on fungi. Swamp and marsh rabbits are direct grazers on herbs and barks. Berries feed wintering birds such as robins, as well as omnivores such as raccoons.

Many species of fish utilize bottomland hardwoods during inundation (Table IV-28). Even some anadromous fishes have adaptations for spawning among inundated bottomland hardwoods (Adams and Street 1969). Fish depend on an annual water level fluctuation to limit intra and interspecific competition for food, space and spawning grounds (Lambou 1959). Trophic pathways of bottomland hardwoods occur in two systems.

The first system is functional when the floodplain is not inundated. At this time the grazing pathway is dominant, with terrestrial fauna utilizing products (nuts, berries, leaves, bark) of primary producers.

The second is a wet system functioning in pools and during the hydro-period of inundated floodplains. It is largely detrital, with primary export into the sloughs and bayous, oxbows and rivers, thus feeding a largely aquatic fauna, although aerial swarms of midge flies, mosquitoes and mayflies emerge periodically and provide a food source for swifts, tree frogs, bats and dragonflies.

Detritus (leaves, twigs) is in the form of coarse particulate matter (CPOM, particle size x_{lmm}), fine particulate matter (FPOM, particle size x_{lmm}), or dissolved organic matter (DOM, particles 0.5 microns) (Cummins and Spenser 1978).

Leaves falling to the forest floor are first enriched by bacteria and aquatic hypomycete fungi which partially digest the plant tissue and leaf tissue which they use to build their own cellular protein. Insect larvae called shredders (Trichoptera, Plecoptera and Diptera) then reduce the leaves to FPOM. Scrapers such as snails may "graze" on the attached periphyton (diatoms) on the CPOM particles. The feces of both groups becomes FPOM.

TABLE IV-28. Mean Standing Crop in Pounds of Fish Per Acre from Three One-Acre Rotenone Samples* Collected Annually from Spring Bayou Backwater Area

Species	Available Size			Intermediate Size			Fingerling Size		
	1962	1963	1964	1962	1963	1964	1962	1963	1964
Predatory Game Fish									
Largemouth bass.....	13.3	14.6	9.5	3.1	...	...	0.4	...	Tr.
Yellow bass.....	0.1	...	...	...	...	0.1	...	...	...
White crappie.....	1.0	...	...	0.2	...	0.1	...	...	0.1
Black crappie.....	39.4	12.8	9.1	2.8	1.3	0.2	0.1	...	0.1
Chain pickerel.....	1.3	2.2	3.1	...	...	...	...	...	...
TOTAL.....	55.1	29.6	21.7	6.1	1.3	0.4	0.5	0.0	0.2
Non-Predatory Game Fish									
Bluegill.....	132.8	61.6	27.5	23.7	0.1	1.8	0.3	...	0.1
Orangespotted sunfish	1.9	...	...	0.6	...	...	0.1	...	...
Redear sunfish.....	29.0	24.3	22.1	4.8	...	0.2	...	...	...
Warmouth.....	12.7	7.3	2.6	2.2	...	0.5	...	...	Tr.
TOTAL.....	176.4	93.2	52.2	31.3	0.1	2.5	0.4	0.0	0.1
Non-Predatory Food Fish									
Freshwater drum.....	8.4	17.2	1.5	...	...	0.3	...	...	...
Bigmouth buffalo.....	34.0	15.0	38.2	0.5	17.0	12.6	...	...	...
Lake chubsucker.....	0.3	...	...	...	...	...	...	...	...
Yellow bullhead.....	0.8	1.8	...	...	...	...	...	...	...
Brown bullhead.....	...	1.2	...	...	...	...	...	...	...
Carp.....	...	...	...	0.7	...	...	...	...	...
TOTAL.....	43.5	35.2	39.7	1.2	17.0	12.9	0.0	0.0	0.0
Predatory Food Fish									
Channel catfish.....	3.0	0.6	1.3	0.6	...	0.4	...	...	...
Spotted gar.....	10.0	15.2	25.6	3.7	2.2	2.3	...	...	...
Shortnose gar.....	...	...	0.8	0.2	...	...	...	...	...
Bowfin.....	3.1	7.0	0.6	...	...	...	...	...	...
TOTAL.....	16.1	22.8	28.3	4.5	2.2	2.7	0.0	0.0	0.0

TABLE IV-28 (continued)

Species	Available Size			Intermediate Size			Fingerling Size		
	1962	1963	1964	1962	1963	1964	1962	1963	1964
Forage Fish									
Gizzard shad.....	94.4	73.6	92.7	38.6	41.4	47.5	0.7	...	...
Threadfin shad.....	...	...	...	...	...	...	...	...	0.2
TOTAL.....	94.4	73.6	92.7	38.6	41.4	47.5	0.7	0.0	0.2
GRAND TOTAL.....	385.5	254.4	234.6	81.7	62.0	66.0	1.6	0.0	0.5
Standing Crop/Acre.....		<u>1962</u>	<u>1963</u>	<u>1964</u>	<u>Mean</u>				
		468.8	316.4	301.1	362.1				

*1962 data averaged from six one-acre samples.

Source: Lance, 1970.

Particulate organic matter is an important source of carbon compounds. Approximately 7.8×10^5 particles per liter of POM were found in a Georgia blackwater stream (Wallace *et al.* 1977). While POM is an important source of carbon compounds for aquatic life, DOM is a far more abundant source. Most of the DOM leaches out of leaves within a few days after falling into the water. Depending on the pH and the presence of divalent cations such as calcium, some DOM can flocculate and form clumps of FPOM. These clumps are then colonized by bacteria and caught by collector organisms. Some bacteria use DOM directly (Lush and Haynes 1973, 1978; Lock and Haynes 1976; Sepers 1977) while others form detrital aggregates (Paerl 1974).

Blackwater systems recycle nutrients poorly and have minimal inputs of inorganic nutrients from the watershed, but have developed extensive animal food chains which utilize organic nitrogen present in detritus and aggregated particles of DOM.

4.7.2.4 Areas of Special Concern. Criteria employed in determining these areas is provided in Section 4.1.1.4.

Due to the "high" elevations bottomland hardwoods occupy, most have been lost due to clearing for agriculture or urbanization. Remaining areas are largely confined to narrow linear transition zones between the swamp forest and agricultural areas. Portions of Marmande Ridge, Bayou Mauvais Bois and other small isolated areas still contain some mixed hardwood habitat that is not bordered by a non-related habitat. These areas serve as important wildlife refuge areas during high water level conditions. In at least one case, the endangered American bald eagle utilizes this habitat as a nesting site (Burke and Associates 1976).

4.7.3 Social.

4.7.3.1 Land Use. See Sections 4.7.2.4 and 4.1.3.1.

4.7.3.2 Cultural Features. Most historic and prehistoric features are located on what is now or formerly was bottomland hardwood forest. See Section 4.1.3.2.

4.7.3.3 Other Programs in the Area. See Section 4.1.3.3.

4.7.4 Economics. See Section 4.1.4.

4.8 Dry Bottomland Hardwood Forest. This habitat is virtually non-existent in Terrebonne Parish, as the highest elevations along the natural levee ridges were among the first areas cleared and settled (see Section 4.1.3.2). This habitat, therefore, has been converted to other upland areas (Section 4.9). Dry bottomland hardwoods are functionally similar, provide a similar habitat and are composed of similar species, but on different assemblages, as wet bottomland hardwood. In a literal sense, dry bottomland hardwood forest has never existed in the area, since the entire parish is comprised of deltaic sediments; therefore all areas had to be inundated at least episodically. See discussions under wet bottomland hardwood forest (4.7 through 4.7.3.3).

4.9 Other Upland Areas. Other upland areas are largely restricted to but include most of the natural levee area in the parish. It

represents the largest area within the projects, comprising a total of 33,594 acres which is 69.3 percent of the total proposed and unauthorized projects' area. Other upland areas include all culturally associated landscapes.

4.9.1 Physical.

4.9.1.1 Meteorological and Climatological. Most of the natural levees are aligned longitudinally in the parish and are therefore subject to the spectrum of hydroclimate variability discussed in Section 4.1.1.5. Additional general climatic information is presented in Section 4.1.1.1.

4.9.1.2 Topological. Elevations of individual levees and associated slopes are discussed in Section 4.1.1.2.

4.9.1.3 Geological. Levee development is discussed in Section 4.1.1.3.

4.9.1.4 Soils. Soils are similar to those discussed in Section 4.7.1.4 except where spoil or other fill has been placed. A listing of soils by habitat type is provided in Table IV-5. Properties of soil types are described in Section 4.1.1.4.

4.9.1.5 Hydrological. Several hydrologic problems associated with other upland areas are precisely what the proposed projects hope to investigate. This issue is addressed throughout Section 2.0.

4.9.1.6 Water Quality. Other upland areas contain most of the non-point source discharges. See Section 4.1.1.6.

4.9.1.7 Air Quality. There are no air quality monitoring stations in the area.

4.9.2 Biological.

4.9.2.1 Flora. Natural volunteer grasses on the levee ridges are bermuda grass, dallis grass, johnson grass, bluestem, vasey grass, carpet grass and St. Augustine grass. St. Augustine grass is the major residential lawn cover throughout the parish. Residents plant many ornamental shrubs and trees for aesthetic purposes. Native tree species found in residential landscapes are live oak, bald-cypress, water oak, pecan, hackberry, American elm, American holly and sycamore.

Major agricultural crops include soybeans and sugarcane. Many acres of natural ridges are utilized as pasture for cattle production. The improved pastures are planted to fescue, dallis grass, bermuda grass and white clover. Rye grass, oats and wheat are seeded for winter grazing. Unimproved pastures provide grazing and hay from volunteer grasses and clovers. These include vasey grass, dallis grass, bluestem, johnson grass, carpet grass, hop clover and white clover.

4.9.2.2 Fauna. The natural ridges provide habitat for many species of non-game mammals and birds. Pastures, fields and residential lawns provide a diversity of habitats which support nongame birdlife such as hawks, cranes, pigeons, owls, goatsuckers, plovers, swifts and hummingbirds, and numerous species of perching birds.

The fields and pastures provide habitat and feeding grounds for game birds like the mourning dove, bobwhite quail, woodcock, and common snipe.

Nongame mammals found in fields, fence rows, drainage canals and ditches and residential lawns include rats, mice, bats, shrews, nine-banded armadillo, nutria, mink and neartic river otter. Game mammals include the eastern cottontail, northern raccoon and Virginia opossum. Swamp rabbits, fox squirrels, grey squirrels and white-tailed deer inhabit the forest-field interface.

4.9.2.3 Ecology. Other upland areas differ considerably from the other habitats discussed previously. Agricultural habitats are simplified systems where most plants and animals are eliminated in favor of selected crops or pasture grasses. Maintenance of this artificial state requires large energy inputs in addition to sunlight, in the form of cultivation, fertilizer, pesticides, herbicides, harvesting and crop preparation and transport. Eutrophic conditions and toxic effects can result in nearby waterbodies from agricultural runoff.

Urban areas also have additional energy and material requirements and produce wastes. A considerable percentage of the urban landscape is in impervious substances (concrete, asphalt, roof material, etc.), resulting in additional runoff.

The effects of development on natural habitats, as well as the anticipated effects the projects will have on development and on natural habitats, are discussed throughout Section 5.0.

4.9.2.4 Areas of Special Concern. No areas of special concern have been identified for other upland areas except for the significant cultural resources discussed in Section 4.1.3.2.

4.9.3 Social.

4.9.3.1 Land Uses. See Section 4.1.3.1.

4.9.3.2 Cultural Features. See Section 4.1.3.2.

4.9.3.3 Other Programs in the Area. See Section 4.1.3.3.

4.9.4 Economics. See Section 4.1.4.

5.0 Environmental Consequences.

5.1 Introduction to this Section. This section will address the probable direct and indirect, beneficial and adverse impacts resulting from construction alternatives as described in Section 3.0. Site specific physical, biological, social and economic impacts resulting from alternative levee alignments will be discussed for each habitat type listed under Section 4.0.

5.2 Effects of No Action Alternative.

5.2.1 Saline Marsh.

5.2.1.1 Physical.

5.2.1.1.1 Meteorological and Climatological. No impact.

5.2.1.1.2 Topological. There will be a probable continued net decrease in elevation due to natural subsidence.

5.2.1.1.3 Geological. There will be a probable continued deterioration of saline marsh due to natural and man-related processes associated with the deterioration phase of the Mississippi River deltaic cycles.

5.2.1.1.4 Soils. There will be a probable eventual deterioration of saline soil profiles (Table IV-5) by erosional processes transforming them to unconsolidated pond and bay sediments.

5.2.1.1.5 Hydrological. There will be a probable increase in frequency and duration of flooding as related to net elevation decrease (Section 5.2.1.1.2).

5.2.1.1.6 Water Quality. No impact.

5.2.1.1.7 Air Quality. No impact.

5.2.1.2 Biological.

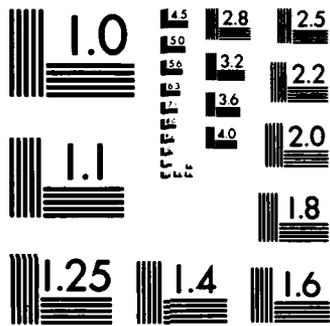
5.2.1.2.1 Flora. There would be a probable gain in saline marsh as brackish marsh converts. However, there would be a probable overall loss of emergent macrophytes.

5.2.1.2.2 Fauna. There would be a probable decrease of non-aquatic fauna as above (Section 5.2.1.2.1). Also, there will be a probable loss of oyster production due to increased predation resulting from inland migration of isohalines.

5.2.1.2.3 Ecology. There would be a probable change from a detrital base marsh system to an aquatic system.

5.2.1.2.4 Areas of Special Concern. All areas of special concern would be adversely impacted.

5.2.1.3 Social.



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5.2.1.3.1 Land Uses. There would be a probable gradual habitat change from marsh to aquatic.

5.2.1.3.2 Cultural Features. There could be a probable loss of pre-historic sites due to erosional processes.

5.2.1.3.3 Other Programs in the Area. No impact.

5.2.1.4 Economics. Monies needed for construction, maintenance and operation of the proposed projects will not materialize. Probable residential, commercial and industrial property loss and damage will continue, resulting from periodic moderate tidal flooding. The probable change in habitats will result in a change of the types and quantities of species harvested. Also, there would be a possible loss of real estate and associated revenues and taxes.

5.2.2 Brackish Marsh.

5.2.2.1. Physical.

5.2.2.1.1 Meteorological and Climatological. No impact.

5.2.2.1.2 Topological. Probable impacts are similar to those described in Section 5.2.1.1.2 under saline marsh.

5.2.2.1.3 Geological. Probable impacts are similar to those described in Section 5.2.1.1.3 under saline marsh. Also there will be some probable gain resulting from conversion of intermediate and fresh marsh to brackish marsh. However, there will probably be an overall net loss.

5.2.2.1.4 Soils. Probable impacts to brackish marsh soils (Table IV-5) are similar to those described in Section 5.2.1.1.4 under saline marsh.

5.2.2.1.5 Hydrological. Probable impacts are similar to those described in Section 5.2.1.1.5 under saline marsh.

5.2.2.1.6 Water Quality. There would be a probable increase in salinity levels.

5.2.2.1.7 Air Quality. No impact.

5.2.2.2 Biological.

5.2.2.2.1 Flora. Probable impacts to brackish marsh flora are similar to those described in Section 5.2.1.2.1 under saline marsh. Also, there may be some gain by the conversion of intermediate and fresh marsh to brackish habitat. Overall there can be expected a probable net loss of brackish marsh flora.

5.2.2.2.2 Fauna. Probable impacts to local fauna are similar to those described in Section 5.2.1.2.2 under saline marsh. With the no action alternative, those species associated with brackish marsh habitat may over a period of time suffer a future loss of habitat.

5.2.2.2.3 Ecology. For much of the brackish marsh, there would be a probable future change from a detrital base marsh to an aquatic system.

5.2.2.2.4 Areas of Special Concern. All brackish marsh areas of special concern will be impacted.

5.2.2.3 Social.

5.2.2.3.1 Land Uses. There will be a probable overall change of habitat type from marsh to aquatic.

5.2.2.3.2 Cultural Features. Probable impacts are similar to those described in Section 5.2.1.3.2 under saline marsh.

5.2.2.3.3 Other Programs in the Area. No impact.

5.2.2.4 Economics. Probable impacts are similar to those described in Section 5.2.1.4 under saline marsh.

5.2.3 Intermediate Marsh.

5.2.3.1 Physical.

5.2.3.1.1 Meteorological and Climatological. No impact.

5.2.3.1.2 Topological. Probable impacts to local topology are similar to those described in Section 5.2.1.1.2 under saline marsh.

5.2.3.1.3 Geological. Probable impacts to local geology are similar to those described in Section 5.2.1.1.3 under saline marsh. Also, there will be some probable net gain resulting from conversion of fresh marsh to intermediate marsh. However, there will probably be an overall loss.

5.2.3.1.4 Soils. Probable impacts to intermediate marsh soils (Table IV-5) are similar to those described in Section 5.2.1.1.3 under saline marsh. Intermediate soils may be converted to brackish or saline soils.

5.2.3.1.5 Hydrological. Probable impacts to local hydrology are similar to those described in Section 5.2.1.1.5 under saline marsh.

5.2.3.1.6 Water Quality. There can be expected a future increase in salinity levels.

5.2.3.1.7 Air Quality. No impact.

5.2.3.2 Biological.

5.2.3.2.1 Flora. Probable impacts to intermediate marsh flora are similar to those described in Section 5.2.1.2.1 under saline marsh. Also, there may be some gain by the conversion of fresh marsh to intermediate marsh habitat. Overall there can be expected a probable net loss of intermediate marsh.

5.2.3.2.2 Fauna. With a probable loss of habitat as per Section 5.2.3.2.1 there will be a decrease of non-aquatic fauna.

5.2.3.2.3 Ecology. For some of the intermediate marsh there will be a change from a detritus producing habitat to an aquatic habitat.

5.2.3.2.4 Areas of Special Concern. All intermediate marsh areas of special concern will suffer some adverse impacts due to erosional forces.

5.2.3.3 Social.

5.2.3.3.1 Land Uses. There may be a change of habitat type from intermediate marsh to brackish or saline marsh or to open water.

5.2.3.3.2 Cultural Features. Probable impacts are similar to those described in Section 5.2.1.3.2 under saline marsh.

5.2.3.3.3 Other Programs in the Area. No impact.

5.2.3.4 Economics. Probable economic impacts to intermediate marsh are similar to those described in Section 5.2.1.4 under saline marsh.

5.2.4 Freshwater Marsh.

5.2.4.1 Physical.

5.2.4.1.1 Meteorological and Climatological. No impact.

5.2.4.1.2 Topological. Probable impacts to local topology are similar to those described in Section 5.2.1.1.2 under saline marsh.

5.2.4.1.3 Geological. Probable impacts to local geology are similar to those described in Section 5.2.1.1.3 under saline marsh. Also, fresh water floatant marsh subjected to saltwater intrusion will convert to open water.

5.2.4.1.4 Soils. Probable impacts to fresh marsh soils (Table IV-5) are similar to those described in Section 5.2.1.1.4 under saline marsh. Also, fresh marsh soils may be converted to intermediate, brackish or saline soils.

5.2.4.1.5 Hydrological. Probable impacts to local hydrology are similar to those described in Section 5.2.1.1.5 under saline marsh.

5.2.4.1.6 Water Quality. There would be a probable increase in salinity levels resulting from natural and man-influenced saltwater encroachments.

5.2.4.1.7 Air Quality. No impact.

5.2.4.2 Biological.

5.2.4.2.1 Flora. Probable impacts to local flora are similar to those described in Section 5.2.1.2.1 under saline marsh. As described in Section 5.2.4.1.3, floatant marsh will probably be converted to open water.

5.2.4.2.2 Fauna. There would a probable decrease in non-aquatic fauna. Also, there may be a decrease in fresh water aquatic species due to probable salinity increases. Species dependant upon fresh marsh habitat will suffer a probable future loss of habitat.

5.2.4.2.3 Ecology. Probable impacts are similar to those described in Section 5.2.1.2.3 for saline marsh.

5.2.4.2.4 Areas of Special Concern. It is probable that all fresh marsh areas of special concern will be subjected to future impacts resulting from continual erosional processes.

5.2.4.3 Social.

5.2.4.3.1 Land Uses. There will be a probable overall change from marsh habitat to aquatic habitat.

5.2.4.3.2 Cultural Features. Probable impacts to fresh marsh cultural features are similar to those described in Section 5.2.1.3.2 under saline marsh.

5.2.4.3.3 Other Programs in the Area. No impact.

5.2.4.4 Economics. Probable impacts to local fresh marsh are similar to those described in Section 5.2.1.4 under saline marsh.

5.2.5 Cypress-Tupelogum Swamp.

5.2.5.1 Physical.

5.2.5.1.1 Meteorological and Climatological. No impact.

5.2.5.1.2 Topological. Probable impacts to swamp topology are similar to those described in Section 5.2.1.1.2 under saline marsh.

5.2.5.1.3 Geological. Probable impacts to local geology are similar to those described in Section 5.2.1.1.3 under saline marsh. Most swamp areas will probably be converted to open water or "ghost swamp".

5.2.5.1.4 Soils. Probable impacts to cypress-tupelogum soils (Table IV-5) are similar to those described in Section 5.2.1.1.4 under saline marsh.

5.2.5.1.5 Hydrological. Probable impacts are similar to those described in Section 5.2.1.1.5 under saline marsh.

5.2.5.1.6 Water Quality. No impact.

5.2.5.1.7 Air Quality. No impact.

5.2.5.2 Biological.

5.2.5.2.1 Flora. There would be a probable reduction of swamp vegetation due to natural erosional processes and salt water intrusion. Also any increased duration of flooding retards or prevents germination of seedlings. There may be some conversion of bottomland hardwoods to swamp. However, overall there would probably be an overall net loss of swamp habitat.

5.2.5.2.2 Fauna. There would be a probable decrease of non-aquatic species. Also, cypress-tupelogum swamp is a favorite nesting habitat of bald eagles, so these birds would be affected by loss of this habitat.

5.2.5.2.3 Ecology. There would be a probable change from a swamp organic system to an aquatic system.

5.2.5.2.4 Areas of Special Concern. All cypress-tupelogum swamp areas of special concern will probably experience future adverse impacts resulting from natural erosional processes.

5.2.5.3 Social.

5.2.5.3.1 Land Uses. There would be a probable gradual habitat change from swamp to aquatic.

5.2.5.3.2 Cultural Features. There could be a probable loss of prehistoric sites due to erosional processes.

5.2.5.3.3 Other Programs in the Area. No impact.

5.2.5.4 Economics. Probable economic impacts are similar to those described in Section 5.2.1.4 under saline marsh.

5.2.6 Wet Bottomland Hardwood Forest.

5.2.6.1 Physical.

5.2.6.1.1 Meteorological and Climatological. No impact.

5.2.6.1.2 Topological. Probable topological impacts are similar to those described in Section 5.2.1.1.2 under saline marsh.

5.2.6.1.3 Geological. Probable impacts are similar to those described in Section 5.2.1.1.3 under saline marsh.

5.2.6.1.4 Soils. Probable impacts to wet bottomland hardwood soils (Table IV-5) are similar to those described in Section 5.2.1.1.4 under saline marsh. Also, bottomland hardwoods may be converted to cypress-tupelo swamps if prolonged freshwater flooding occurs.

5.2.6.1.5 Hydrological. Probable impacts are similar to those described in Section 5.2.1.1.5 under saline marsh.

5.2.6.1.6 Water Quality. Probable impacts to water quality consist of increased salinity levels.

5.2.6.1.7 Air Quality. No impact.

5.2.6.2 Biological.

5.2.6.2.1 Flora. There would be a probable reduction of wet bottomland hardwood vegetation due to natural erosional processes.

5.2.6.2.2 Fauna. There would be a probable decrease of non-aquatic species.

5.2.6.2.3 Ecology. There would be a probable gradual change from a wet bottomland organic system to an aquatic system.

5.2.6.2.4 Areas of Special Concern. All wet bottomland hardwood areas of special concern will be subjected to future adverse impacts resulting from natural erosional processes and saltwater intrusion.

5.2.6.3 Social.

5.2.6.3.1 Land Uses. There would be a probable gradual habitat change from wet bottomland hardwoods to cypress-tupelo swamp or open water depending on salinity levels of encroaching flood waters.

5.2.6.3.2 Cultural Features. There could be a probable loss of prehistoric sites due to erosional processes.

5.2.6.3.3 Other Programs in the Area. No impact.

5.2.6.4 Economics. Probable impacts to wet bottomland hardwood economics are similar to those described in Section 5.2.1.4 under saline marsh.

5.2.7 Dry Bottomland Hardwood Forest. This habitat does not exist within Terrebonne Parish (see Section 4.8).

5.2.8 Other Upland Areas.

5.2.8.1 Physical.

5.2.8.1.1 Meteorological and Climatological. No impact.

5.2.8.1.2 Topological. Probable impacts to local topology are similar to those described in Section 5.2.1.1.2 under saline marsh.

5.2.8.1.3 Geological. Local upland geology will probably be subjected to future impacts resulting from the natural deterioration phase of the Mississippi deltaic cycles.

5.2.8.1.4 Soils. Upland soils (Table IV-5) along the lower reaches of the natural distributary ridges will probably be subjected to future erosional processes, converting these soils into other habitat types or unconsolidated water body sediments.

5.2.8.1.5 Hydrological. Probable impacts to local hydrology are similar to those described in Section 5.2.1.1.5 under saline marsh.

5.2.8.1.6 Water Quality. Water quality may be impacted by encroachment of isohaline boundaries.

5.2.8.1.7 Air Quality. No impact.

5.2.8.2 Biological.

5.2.8.2.1 Flora. Probable eventual conversion to wetland habitats resulting from saltwater intrusion and erosion.

5.2.8.2.2 Fauna. Those species indigeous to upland areas will suffer a loss of habitat resulting from eventual conversion forces of saltwater intrusion and erosion.

5.2.8.2.3 Ecology. Ecology of uplands will most probably and eventually be converted by saltwater intrusion and erosional processes to wetland ecological systems.

5.2.8.2.4 Areas of Special Concern. No impact.

5.2.8.3 Social.

5.2.8.3.1 Land Uses. Marginal uplands along the lower reaches of the distributary ridges now used for agriculture and development will probably experience future increases in flooding as a result of natural deterioration processes.

5.2.8.3.2 Cultural Features. There could be a probable loss of pre-historic and historic sites due to erosional forces.

5.2.8.3.3 Other Programs in the Area. No impact.

5.2.8.4 Economics. Monies needed for construction, maintenance and operation of the proposed projects will not materialize. Probable residential, commercial and industrial property loss and damage will continue, resulting from probable increased tidal and precipitation flooding. The possible loss of productive real estate resulting from increased flooding also would cause loss of associated revenues and taxes.

5.3 Effects of Non-wetland Alternative.

5.3.1 Saline Marsh.

5.3.1.1 Physical.

5.3.1.1.1 Meteorological and Climatological. Construction activities and placement of the proposed collection canal and levee may cause some indirect adverse impacts to adjacent wetlands. Most of the probable indirect wetland impacts would result from construction impacts on local hydrology as described in Section 5.3.1.1.5.

Alteration of wetlands can modify local climatic conditions. Wetlands and water bodies are of importance in weather processes such as amelioration of freeze conditions, modification of lake and sea breezes, and tropical cyclone behavior after landfall (Gannon et al. 1978).

Wetlands modify temperature and moisture content of the lower atmosphere. Atmospheric circulation patterns are affected by area, depth, and distribution of wetlands. The patterns are influenced by communication of direct (sensible) and latent heat (by evapotranspiration) to the atmosphere. Small scale weather systems (e.g. lake breezes) can be initiated or modified by differential surface heating patterns resulting from local and regional topographical inhomogeneities such as variable

land and water distributions. In this context, wetlands strongly influence local and regional weather and climate. The most significant changes occur when water surfaces are drained or replaced with impermeable materials such as rocks, granite, asphalt, concrete, etc.

5.3.1.1.2 Topological. No impact.

5.3.1.1.3 Geological. No impact.

5.3.1.1.4 Soils. No impact.

5.3.1.1.5 Hydrological. This alternative will not impact existing tidal flows of saline marshes adjacent to project areas. Local area hydrology will be impacted by point source discharges during pump station operation. Proposed project levees will prevent overland sheet flow by concentrating flow to a point source discharge. This will result in a minor loss of fresh water flow to some areas and a major increase of freshwater flow to other areas. Also, project construction will provide an incentive for development, resulting in increased runoff.

5.3.1.1.6 Water Quality. Local water quality may be adversely impacted by point source discharges. Accumulation of nutrients may lead to localized eutrophication. Also, there may be some accumulation of pesticides and heavy metals at discharge points.

5.3.1.1.7 Air Quality. Local construction area air quality may suffer low level short-term adverse impacts resulting from construction equipment exhaust emissions. Also, local air quality at proposed pump station locations may suffer low level short-term adverse impacts from exhaust emissions during pump station operation.

5.3.1.2 Biological.

5.3.1.2.1 Flora. Probable impacts to saline marsh vegetation may consist of extremely localized changes to fresher habitats at pump discharge sites.

5.3.1.2.2 Fauna. Species native to saline habitat will not be directly impacted by dredge and disposal activities. Some benthic and microorganisms which inhabit the wetland/non-wetland edge of saline marshes may suffer from salinity changes and nutrient reductions resulting from levee construction blocking off overland sheet flows.

The timing or seasonality of the rain input may also be critical to primary productivity. The availability of dissolved nutrients for plant growth is a function of concentration (i.e. source) of the nutrients and of renewal (Gorham 1957 and Newbould 1960). For example, in smooth cord-grass marshes of coastal Massachusetts, N is limited in inland marshes but not in streamside marshes, presumably because the frequent flushing of the latter results in a larger total N supply (Veliela et al. 1975).

The availability of nutrients bound to particulate materials is also strongly influenced by hydrodynamic considerations, particularly the velocity of flooding waters. The higher the flooding velocity the greater the sediment input and the more vigorous the plant growth (Delaune et al. 1976). This is quite evident in the well known "edge effect", the stimulation of production along stream banks (Buttery et al. 1965).

In addition to nutrients, the source of water is also a source of toxins. Probably the most ubiquitous of these are salts, usually associated with sea water (Gosselink and Turner 1978). The regular renewal of water at lower elevations prevents salt accumulation.

Other toxins, such as herbicides and pesticides, are also carried into wetlands by flood waters. With the non-wetland alternative, these toxins will be introduced into wetlands at a point source discharge. Frequency and velocity of flooding are important in determining the total amount available to wetland flora and fauna (Gosselink and Turner 1978).

Saturated wetlands' experiencing low renewal rates causes a depletion of O_2 in the substrate and leads to a number of chemical changes, which together have a significant effect on plant productivity.

5.3.1.2.3 Ecology. Only the ecology of those small niches along the wetland/non-wetland interface dependant upon freshwater input may be irretrievably altered by project construction.

5.3.1.2.4 Areas of Special Concern. The non-wetland alternative will not adversely impact any salt marsh areas of special concern. In some areas the proposed non-wetland alternative may help to prevent continued erosion of valuable uplands caused from salt water intrusion.

5.3.1.3 Social.

5.3.1.3.1 Land Uses. No impact.

5.3.1.3.2 Cultural Features. No impact.

5.3.1.3.3 Other Programs in the Area. No impact.

5.3.1.4 Economics. No impact.

5.3.2 Brackish Marsh.

5.3.2.1 Physical.

5.3.2.1.1 Meteorological and Climatological. Probable impacts to local climatic conditions are similar to those described in Section 5.3.1.1.1 for saline marsh.

5.3.2.1.2 Topological. No impact.

5.3.2.1.3 Geological. No impact.

5.3.2.1.4 Soils. No impact.

5.3.2.1.5 Hydrological. Probable impacts to local hydrology are similar to those described for saline marsh in Section 5.3.1.1.5.

5.3.2.1.6 Water Quality. Probable brackish marsh water quality impacts are similar to those described in Section 5.3.1.1.6 under saline marsh.

5.3.2.1.7 Air Quality. Probable air quality impacts are similar to those described in Section 5.3.1.1.7 under saline marsh.

5.3.2.2 Biological.

5.3.2.2.1 Flora. Probable impacts to brackish marsh vegetation are similar to those described in Section 5.3.1.2.1 under saline marsh.

5.3.2.2.2 Fauna. Probable impacts to brackish marsh fauna are similar to those described in Section 5.3.1.2.2 under saline marsh.

5.3.2.2.3 Ecology. Probable impacts to brackish marsh ecology are similar to those described in Section 5.3.1.2.3 under saline marsh.

5.3.2.2.4 Areas of Special Concern. Probable impacts to brackish marsh areas of special concern are similar to those described in Section 5.3.1.2.3 under saline marsh.

5.3.2.3 Social.

5.3.2.3.1 Land Uses. No impact.

5.3.2.3.2 Cultural Features. No impact.

5.3.2.3.3 Other Programs in the Area. No impact.

5.3.2.4 Economics. No impact.

5.3.3 Intermediate marsh.

5.3.3.1 Physical.

5.3.3.1.1 Meteorological and Climatological. Probable impacts to local climatic conditions are similar to those described in Section 5.3.1.1.1 for saline marsh.

5.3.3.1.2 Topological. No impact.

5.3.3.1.3 Geological. No impact.

5.3.3.1.4 Soils. No impact.

5.3.3.1.5 Hydrological. Probable impacts to local hydrology are similar to those described in Section 5.3.1.1.5 for saline marsh.

5.3.3.1.6 Water Quality. Probable water quality impacts are similar to those described in Section 5.3.1.1.6 under saline marsh.

5.3.3.1.7 Air Quality. Probable impacts to local air quality are similar to those described in Section 5.3.1.1.7 for saline marsh.

5.3.3.2 Biological.

5.3.3.2.1 Flora. Probable impacts to intermediate marsh flora are similar to those described in Section 5.3.1.2.1 under saline marsh.

5.3.3.2.2 Fauna. Probable impacts to intermediate marsh fauna are similar to those described in Section 5.3.1.2.2 for saline marsh.

5.3.3.2.3 Ecology. Intermediate marsh ecology impacts will be similar to those described in Section 5.3.1.2.3 for saline marsh.

5.3.3.2.4 Areas of Special Concern. No impact.

5.3.3.3 Social.

5.3.3.3.1 Land Uses. No impact.

5.3.3.3.2 Cultural Features. No impact.

5.3.3.3.3 Other Programs in the Area. No impact.

5.3.3.4 Economics. No impact

5.3.4 Freshwater Marsh.

5.3.4.1 Physical.

5.3.4.1.1 Meteorological and Climatological. Probable impacts to local climatic conditions are similar to those described in Section 5.3.1.1.1 for saline marsh.

5.3.4.1.2 Topological. Probable impacts to local topology are similar to those described in Section 5.3.1.1.2 for saline marsh.

5.3.4.1.3 Geological. This proposed alternative will not impact existing local geology.

5.3.4.1.4 Soils. Probable impacts to fresh marsh soils are similar to those described for saline marsh in Section 5.3.1.1.4.

5.3.4.1.5 Hydrological. Probable impacts to local fresh marsh hydrology are similar to those described in Section 5.3.1.1.5 under saline marsh. Hydrology plays a key role in controlling wetland ecosystems. The source, velocity, renewal rate, and timing of water in a wetland ecosystem directly control the spatial heterogeneity of wetlands and the nutrient, O_2 , and toxin load of sediments (Gosselink and Turner 1978). These secondary factors in turn control or modify such ecosystem characteristics as species composition and richness, primary productivity, organic deposition and flux and nutrient cycles.

The hydrologic regime is a major factor affecting spatial diversity. The greater the spatial heterogeneity the greater the number of niches, and the more opportunity for a successful invasion by a species (Jacobs 1975). The hydrologic regime can contribute to the elevational and substrate differences, which are a chief source of species diversity in wetlands (Hinde 1954).

The fate of excess primary production is strongly influenced by the hydrologic regime. Gosselink *et al.* (1977) showed that as the frequency of inundation of coastal marshes decreases, the inorganic concentration and particle size of the marsh sediments decrease, and organic

concentration increases; that is, flooding frequency is directly related to inorganic silt input and to organic export.

5.3.4.1.6 Water Quality. Probable impacts to local water quality are similar to those described in Section 5.3.1.1.6 under saline marsh. Also, reduction of freshwater inputs in some areas will probably lead to increased salinity levels.

5.3.4.1.7 Air Quality. Local air quality may be impacted as described in Section 5.3.1.1.7 under saline marsh.

5.3.4.2. Biological.

5.3.4.2.1 Flora. No impact.

5.3.4.2.2 Fauna. Probable impacts to local fauna are similar to those described in Section 5.3.1.2.2 under saline marsh.

5.3.4.2.3 Ecology. Levee construction and elimination of sheet flows will alter the local hydrology, which in turn will impact local ecological processes dependent on freshwater, sediment and nutrient inputs.

5.3.4.2.4 Areas of Special Concern. No impact.

5.3.4.3 Social.

5.3.4.3.1 Land Uses. No impact.

5.3.4.3.2 Cultural Features. No impact.

5.3.4.3.3 Other Programs in the Area. No impact.

5.3.4.4 Economics. No impact.

5.3.5 Cypress-Tupelogum Swamp.

5.3.5.1 Physical.

5.3.5.1.1 Meteorological and Climatological. Probable impacts to local climate are similar for those described in Section 5.3.1.1.1 for saline marsh.

5.3.5.1.2 Topological. No impact.

5.3.5.1.3 Geological. No impact.

5.3.5.1.4 Soils. No impact.

5.3.5.1.5 Hydrological. Probable impacts to local cypress-tupelogum swamp are similar to those described in Section 5.3.1.1.5 under saline marsh.

5.3.5.1.6 Water Quality. Probable eutrophication may occur from levee construction resulting in point source discharge of nutrient-laden

runoff directly to swamp lakes as previously described in Section 5.3.1.1.5 under saline marsh.

5.3.5.1.7 Air Quality. Probable impacts to local air quality are similar to those described in Section 5.3.1.1.7 for saline marsh.

5.3.5.2 Biological.

5.3.5.2.1 Flora. Swamp flora may be indirectly impacted by hydrological changes resulting from levee construction. The availability of nutrients bound to particulate materials is strongly influenced by hydrodynamic considerations, particularly the velocity of flooding waters. The higher the flooding velocity the greater the sediment input and the more vigorous the plant growth (Delaune et al. 1976). Also, saturated wetlands' experiencing low renewal rates causes a depletion of O_2 in the substrate and leads to a number of chemical changes which together have a significant effect on plant productivity.

5.3.5.2.2 Fauna. Swamp fauna may be impacted, resulting from probable hydrological and vegetational changes at pump station discharge points. However, swamp terrestrial and avian fauna may be affected in the future by possible gradual vegetational impacts described in Section 5.3.5.2.1.

5.3.5.2.3 Ecology. Local ecology may be impacted by hydrological changes. The source, velocity, renewal rate and timing of the water input in a wetland ecosystem directly control the spatial heterogeneity of wetlands, and the nutrients, oxygen, and toxin load of the sediments. These secondary factors in turn control or modify such ecosystem characteristics as species composition and richness, primary productivity, organic deposition and flux, and nutrient cycles. Construction of drainage canals and levees causes two major probable impacts to receiving swamplands: (1) high drainage densities lead to eutrophication of water bodies (Gael and Hopkinson 1979; Seaton 1979; Day et al. 1977; Lantz 1970; Craig and Day 1977; Kemp 1978). Gael and Hopkinson found a direct positive linear correlation between drainage density and trophic state condition of water bodies. This is because nutrient-laden runoff water from the uplands flows directly to swamp lakes via the network of canals rather than through overland flow; (2) spoil banks parallel to canals and bayous prevent overbank flooding, retard water and material exchange and cause prolonged ponding and stagnation. This has led to decreased biomass and productivity and species changes in the swamp forest (Conner and Day 1976, Craig and Day 1977).

Hopkinson and Day (1980) applied the EPA Storm Water Management Model to Lac Des Allemands Swamp Basin to simulate stormwater and nutrient runoff resulting from projected land use changes between 1975 and 1995. This simulation is a good example of probable impacts in Terrebonne Parish, since the project area is similar in physiography. Also the existing land uses are similar. That is, the project area is clearly being urbanized and industrialized; agricultural land is declining; and the trophic state of receiving water bodies in the swamp is increasing.

Simulations showed that runoff volumes and nutrient loading will increase greatly by 1995, if the projected changes in land use are realized. The major reasons for this are the increased area of urban land

that has (1) a higher availability of nutrients and (2) hydraulic properties that lead to more rapid and greater runoff. With increased nutrient loading to the swamp, model results suggest that the problem of eutrophication of receiving water bodies will continue.

5.3.5.2.4 Areas of Special Concern. No impact.

5.3.5.3 Social.

5.3.5.3.1 Land Uses. No impact.

5.3.5.3.2 Cultural Features. No impact.

5.3.5.3.3 Other Programs in the Area. No impact.

5.3.5.4 Economics. Swamp economics may be impacted by possible localized eutrophic conditions which affect harvestable commercial aquatic populations such as the red swamp crawfish.

5.3.6 Wet Bottomland Hardwood Forest.

5.3.6.1 Physical.

5.3.6.1.1 Meteorological and Climatological. Probable impacts to local climate are similar to those described in Section 5.3.1.1.1 for saline marsh.

5.3.6.1.2 Topological. No impact.

5.3.6.1.3 Geological. No impact.

5.3.6.1.4 Soils. No impact.

5.3.6.1.5 Hydrological. Probable impacts to local hydrology will be similar to those described in Section 5.3.1.1.5 for saline marsh.

5.3.6.1.6 Water Quality. Existing water quality may be impacted by probable localized eutrophication resulting from levee construction and point source discharge of nutrient laden waters directly into receiving water bodies. Also reduction of freshwater input could result in increased salinity levels.

5.3.6.1.7 Air Quality. Local air quality impacts will be similar to those described in Sections 5.3.1.1.7 for saline marsh.

5.3.6.2 Biological.

5.3.6.2.1 Flora. Proposed levee construction and resulting alteration of frequency, duration and depth of flooding, and shifts in soil texture and layering as a result of floods can impact diversity and composition of hardwood forests (Lindsey *et al.* 1961; Bedinger 1971; Johnson and Bell 1976; and Solomon 1977). Flood frequency and duration may be the most important factor in determining plant species distribution in lowland forests because of the irregular horizontal and vertical distribution of alluvial soils (Bedinger 1971).

5.3.6.2.2 Fauna. Local fauna may suffer future impacts resulting from probable impacts to habitat composition as described in above Section 5.3.6.2.1.

5.3.6.2.3 Ecology. Local ecology may be impacted as described in Section 5.3.5.2.3 under cypress-tupelogum swamp.

5.3.6.2.4 Areas of Special Concern. No impact.

5.3.6.3 Social.

5.3.6.3.1 Land Uses. No impact.

5.3.6.3.2 Cultural Features. No impact.

5.3.6.3.3 Other Programs in the Area. No impact.

5.3.6.4 Economics. No impact.

5.3.7 Dry Bottomland Hardwood Forests. See Section 4.8.

5.3.8 Other Upland Areas.

5.3.8.1 Physical.

5.3.8.1.1 Meteorological and Climatological. Probable impacts are similar to those described in Section 5.3.1.1.1 for saline marsh.

5.3.8.1.2 Topological. Local topology will be impacted by canal excavation and deposition of dredged material for levee construction.

5.3.8.1.3 Geological. No impact.

5.3.8.1.4 Soils. Existing upland soil profiles (Table IV-5) within construction corridors will be disrupted by dredging and disposal activities.

5.3.8.1.5 Hydrological. Local uplands hydrology may be impacted by construction of drainage ditches and the artificial routing of runoff to the forced drainage collection canals.

5.3.8.1.6 Water Quality. No impact.

5.3.8.1.7 Air Quality. Probable impacts to local air quality are similar to those described in Section 5.3.1.1.7 for saline marsh.

5.3.8.2 Biological.

5.3.8.2.1 Flora. Vegetation within the existing construction right-of-way will be destroyed by clearing, dredging and disposal activities. Existing rights-of-way will be kept clear of overstory vegetation for maintenance purposes.

5.3.8.2.2 Fauna. Species within construction rights-of-way may be destroyed or displaced by clearing, dredging and disposal activities. Addition of displaced animals to adjacent habitats may cause interspecific

and intraspecific competition among individuals, which can lead to environmental stress (Table V-1) and reduced carrying capacity of other habitats. Those upland species may suffer a loss of habitat resulting from canal excavation.

5.3.8.2.3 Ecology. Local ecology will be impacted by the alteration or loss of upland habitat and disruption of local communities and niches.

5.3.8.2.4 Areas of Special Concern. No impact.

5.3.8.3 Social.

5.3.8.3.1 Land Uses. Existing undeveloped non-wetlands which are in demand for residential, commercial, industrial and agricultural development may be utilized for canal and levee construction.

5.3.8.3.2 Cultural Features. No known cultural features would be directly impacted by construction activities. In some cases the canal and levee may contribute to aesthetic degradation of existing cultural landscapes.

5.3.8.3.3 Other Programs in the Area. No impact.

5.3.8.4 Economics. Probable future revenues may be adversely impacted by utilizing probable residential, commercial, industrial and agricultural land for canal and levee construction. On the other hand, the proposed parishwide forced drainage program will be beneficial to the local community and regional growth by converting marginal uplands once subject to periodic flooding to areas desirable for residential, commercial and industrial utilization. Development of these once marginal areas will increase property values and expand the local tax base.

With the present project design there will be no displacement of people or relocation of structures resulting from levee and canal construction. Construction noise levels will be temporary and longterm noise sources such as emitted from proposed pumping stations will not exceed acceptable tolerable limits.

It is anticipated that esthetic degradation will be minor and will not severely impact any unique esthetic area or structure. As proved by existing drainage projects esthetic degradation is negligible and accepted by the general public as necessary for flood protection.

The proposed project as demanded by the residents of Terrebonne will provide drainage facilities parishwide and should not disrupt community cohesion. Also proposed levee alignments will not interfere with existing cultural boundaries.

It is not anticipated that the proposed project will impact existing and future public facilities or services beyond projected parish growth.

Project construction and future maintenance of levees and pump stations will provide additional local job opportunities.

The proposed project will not adversely impact production or consumption of existing or future energy sources.

The proposed drainage program will not impact existing flood control projects or waterborne commerce.

TABLE V-1. Generalized Biological Response Patterns to Increased Levels of Environmental Stress. Response is given for several different levels of biological organization. Entries within a given vertical column are meant to indicate trends of response pattern. Habitat elimination sends all columns to bottom entry.

Degree of Stress	Response at indicated level of organization			Community
	Individual organism	Population	Species	
Moderate	Some metabolic and behavioral interference. Reduced competitive ability. Reduced resistance to parasites and predators. Reduced capacity for reproduction.	Reduced competitive ability of most sensitive individuals. Some genetic selection for more tolerant individuals.	Most sensitive populations undergoing selection for hardiest individuals, hence losing genetic diversity. Most tolerant populations little affected.	Noticeable shifts in relative species abundance as the most sensitive species suffer reduction in numbers while more tolerant competitor species remain the same or increase in abundance.
Heavy	Individual under heavy stress load. Survival not in jeopardy, but individual weakened and susceptible to parasites, disease, and predation. Reproduction greatly curtailed.	Elimination of most sensitive individuals. Increase in more tolerant individuals. Population level may or may not be affected. Reduction in genetic diversity.	Most sensitive populations eliminated. Most tolerant populations losing sensitive individuals, hence losing genetic diversity.	Significant shifts in species composition as sensitive species are eliminated and hardy competitors remain and often increase. New hardy species may enter from elsewhere.
Severe	Severe metabolic and behavioral interference. Individual survival in question. Reproduction no longer possible.	Survival of only the most tolerant individuals. Population level may or may not be reduced. Severe reduction in genetic diversity.	Only the hardiest individuals of the most tolerant populations still survive.	Great shifts in species composition. Most species reduced or eliminated. Hardy species may become very abundant. Total system greatly simplified. Community metabolism greatly modified. Stability severely reduced.
Total	Death	Elimination	Extinction	Collapse

5.4 Effects of the Wetland/Non-Wetland Interface Alternative.

5.4.1 Saline Marsh.

5.4.1.1 Physical.

5.4.1.1.1 Meteorological and Climatological. Probable impacts to local climatic conditions resulting from project construction are similar to those described in Section 5.3.1.1.1 under saline marsh.

5.4.1.1.2 Topological. Changes of natural ground elevations will occur within construction rights-of-way resulting from canal excavation and levee construction. Probable subsidence increase along levee flanks will result from increased compaction due to deposition of dredged material for levee construction. Adjacent marsh habitats may also experience long-term elevational changes. Project construction will directly impact vegetational communities and prevent incoming sediments carried by sheetflows. Entrapment and stabilization of suspended inorganic sediment on the marsh surface by vegetation is an important process in maintaining elevation with respect to sea level. Incoming sediment also supplies nutrients for plants, which in turn enhance further sediment entrapment and stabilization. Impacts to vegetation can result in the marsh's inability to maintain itself in the face of naturally occurring subsidence.

5.4.1.1.3 Geological. No impact.

5.4.1.1.4 Soils. Existing soil profiles (Table IV-5) within the construction corridor will be impacted by dredging and disposal activities. The cutting and digging action of the dredging operation breaks through the thin oxidized layer to the submerged soil and exposes the deep unoxidized layer. The reduced layers of submerged soil act as a chemical trap for most nutrients, including phosphorus, iron, manganese, silicon, cobalt, nickel and zinc. In addition, the disturbance of oxidized and reduced layers results in the loss of much nitrogen through denitrification from usable chemical forms (especially nitrate and ammonia) to the generally unusable gaseous nitrogen which escapes to the overlying water and eventually to the atmosphere.

5.4.1.1.5 Hydrological. Probable impacts to local hydrology are similar to those described in Section 5.3.1.1.5 and 4.1.1.5.7.

5.4.1.1.6 Water Quality. Impacts to water quality may result from wetland destruction and elimination of sheet flows through wetland areas. Wetlands affect water quality through element cycling, sediment deposition, ion and molecule absorption, and temperature modification.

As early as 1932, Beadle, studying water quality in African lakes, noted that water quality was much better in a lake where the inflow passed through a wetland than in an adjacent lake without wetlands. In recent years, many authors have suggested that wetlands are excellent nutrient traps and are as a result valuable because they are acting as natural treatment plants, removing N and P from polluted water passing through them (Wharton 1970).

Van der Valk et al. (1978) reviewed 17 studies on natural wetlands as nutrient (N,P) traps or sinks for polluted water passing through them. All 17 studies showed that wetlands improve water quality to some extent;

that is, all the wetlands trapped P and/or N at least seasonally. Although the studies varied greatly in quality, there is a remarkable consistency in the data considering that data included are (1) from all four basic hydrologic types of wetlands (riverine, tidal, lacustrine, and palustrine); (2) from temperate, subtropical and tropical wetlands; (3) from both herb (marshes) and tree (swamps) dominated wetlands; and (4) from three continents.

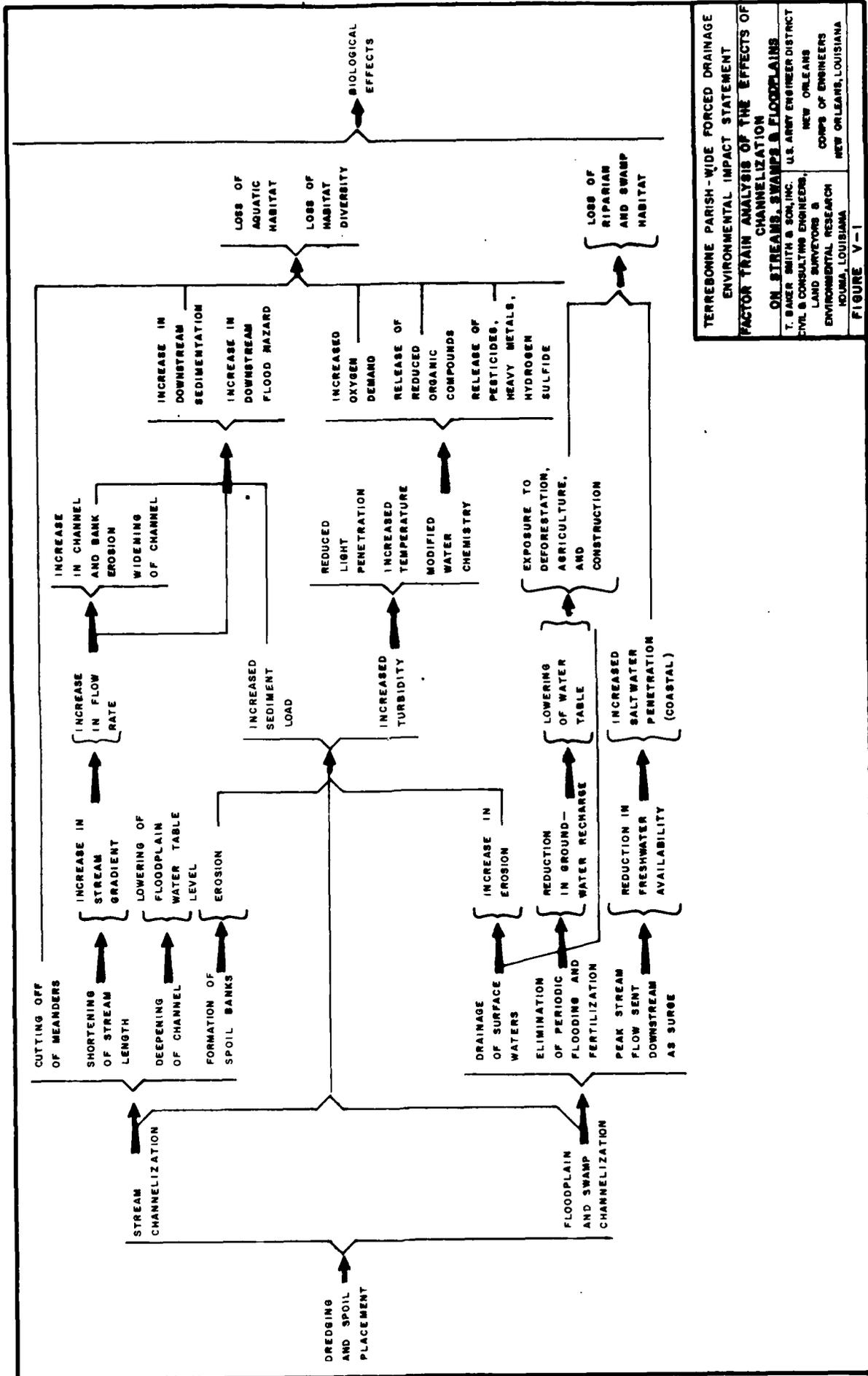
Increased turbidity caused by dredging and filling has been shown to affect ambient water quality (Figure V-1). Dissolved oxygen concentrations near dredging operations have been shown to be markedly lower than concentrations measured away from these operations. This may be attributed to resuspension of bottom sediments, which increases turbidity, settleable and suspended solids, and biochemical oxygen demand (Brown and Clark 1968).

Suspended sediments almost always reduce the oxygen concentration of natural waters. Suspended sediments absorb radiant energy from sunlight and transform this into heat. Surface waters are warmed and in relatively calm water, increased temperatures stabilize the water column and inhibit vertical mixing. Deprived of access to the atmosphere, the bottom waters develop low oxygen conditions and may become anaerobic. Also, removal of flood plain vegetation eliminates shading and leads to temperature elevation in streams (Gray and Edington 1969).

Many types of sedimentary particles contain chemically reduced substances such as sulfides, especially if they are raised from bottom sediments as through dredging. Such suspended particles have a chemical oxygen demand (C.O.D.) and may remove appreciable quantities of oxygen from the water. Most suspended particles become coated with bacteria and other microorganisms which decompose organic matter and create a biological oxygen demand. If the level of organic matter is high, then anaerobic conditions may result. Biological oxidation in turn leads to increased levels of carbon dioxide, and results in decreased pH (Darnell 1976).

Darnell (1976) indicated that toxic materials such as hydrogen sulfide, methane, and a variety of organic acids, ketones, aldehydes, etc. as well as heavy metals and pesticides which exhibit persistent toxic effects, may be released into the water column during dredge and fill activities, although no evidence exists to indicate their presence.

The bioavailability of toxic and potentially toxic metals depends on the chemical form of the metals in sediment-water systems. Chemical combinations of metals in sediment-water systems may be grouped into three general availability categories. Metals dissolved in surface and interstitial waters are considered most available to living organisms. Easily exchangeable metals are those weakly adsorbed to the fixed negatively charged sides of clays and organics which may be desorbed and enter the aqueous phase by complex equilibrium reaction or by mass action. This form is also considered readily available. On the opposite end of the availability spectrum are those metals bound within the crystalline lattice of primary and secondary minerals. These metals are essentially unavailable to biota and may become available only over geologic time by mineral weathering. Between these extremes are numerous chemical forms of metals which are potentially available to biota. Metals in these



TERREBONNE PARISH - WIDE FORCED DRAINAGE
 ENVIRONMENTAL IMPACT STATEMENT
 FACTOR TRAIN ANALYSIS OF THE EFFECTS OF
 CHANNELIZATION
 ON STREAMS, SWAMPS & FLOODPLAINS
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 NEW ORLEANS, LOUISIANA

FIGURE V-1

potentially available chemical combinations may be transformed to the more readily bioavailable forms by chemical or biological processes resulting from relatively mild changes in the physio-chemical environment of a sediment-water system.

The pH and redox potential (degree to oxidation or reduction) of soils, sediments, and surface waters are two important physiochemical properties regulating chemical forms of toxic metals affecting their bioavailability. A change in these parameters may result in chemical transformations influencing the bioavailability of metals in dredged sediments by directly affecting the chemical speciation of a metal (e.g., altering valence charge), or by affecting the presence of ligands which regulate the mobilization or immobilization of toxic heavy metals.

5.4.1.1.7 Air Quality. Probable impacts to local air quality are similar to those described in Section 5.3.1.1.7 under saline marsh.

5.4.1.2 Biological.

5.4.1.2.1 Flora. Both wetland and non-wetland vegetation along the interface will be adversely impacted or destroyed by clearing, dredging, and fill activities.

Additions of turbid dredge material containing inorganic nutrients can indirectly stimulate photosynthesis (Sherk 1971). Interference with photo-synthesis can destroy phytoplankton (Buck 1956), attached algae (King and Ball 1964), and rooted vegetation (Wilson 1957; Verdin 1954), thus eliminating the food base of aquatic ecosystems (Darnell 1976).

Suspended solids, especially fine particulate matter, can efficiently remove certain types of phytoplankton organisms from suspension.

Phinney (1959) concluded that sedimentation reduces the photosynthetic rate of aquatic vegetation by acting as a physical barrier to free exchange of gases (oxygen and carbon dioxide) necessary for their survival. Thus primary production is inhibited not only by turbidity and the effects of suspended solids, but also by scouring and smothering.

5.4.1.2.2 Fauna. Terrestrial and aquatic species occurring within construction rights-of-way will be adversely impacted by construction activities. Less mobile species such as invertebrates will probably be destroyed by dredging and disposal activities. Most mobile species will relocate in adjacent habitats but will suffer a loss of saline marsh habitat. Relocation to adjacent habitats may cause competition among individuals resulting in environmental stress as described in Section 5.3.8.2.2. However, levee construction will provide upland habitat bordering wetlands which will provide an edge effect and increase habitat diversity.

Aquatic organisms may be adversely impacted by poor water quality resulting from construction activities. Reduction or elimination of submerged vegetation creates a number of problems in addition to the loss of a primary production source. Organisms may suffer from locally high oxygen demands resulting from decaying vegetation. Also, the reduction of vegetation and photosynthesis will reduce the quantity of oxygen being produced within a body of water.

Decreased visibility, resulting from increased turbidity, has been shown to interfere with normal behavior patterns of some fishes. Heimstra and Damkot (1969) compared the behavior of largemouth bass and green sunfish in clear water with that in two conditions of mild turbidity. They found that the experimental fishes showed a marked reduction in general swimming activity, social dominance patterns were modified and fishes frequently engaged in "coughing" and gill-scraping behavior (both mechanisms apparently aid in freeing the gills of accumulated particulate material). Coarse particles in suspension may harm fish by causing abrasion of the body surface, which may remove protective mucus and increase susceptibility to invasion by parasites or disease (Everhart and Duchrow 1970). Also, mechanical or abrasive action of suspended silt and detritus is detrimental to filter-feeding organisms with respect to gill clogging, impairment of proper respiratory and excretory functioning, and feeding activity (Sherk 1971).

Dredging and turbid conditions may impact chemical substances in the water which provide important cues governing the daily and seasonal behavior of aquatic animals. Location of food, recognition of breeding, migrator orientation, alarm and avoidance are some of the behavior patterns known to depend, at least in part, upon chemical cues.

Temperature exerts a controlling influence on the lives of aquatic organisms. All have upper and lower thermal tolerance limits, optimum temperatures for growth, preferred temperatures in thermal gradients and temperature limitations for migration, spawning and egg incubation.

Sedimentation adversely affects fish populations in three ways: it reduces or eliminates the food supply, it destroys fish habitat by filling pools or undercuts along banks, and it adversely affects reproduction by elimination of spawning areas or smothering the eggs and larvae after spawning has been completed.

The release of toxicants from dredge sediments into estuarine waters can cause severe harm to the biological resources residing in these areas. Contaminated dredge material has been linked in marine organisms to the occurrence of diseases such as finrot and shell erosion in crabs, lobsters, and other crustacea (Palmer and Gross 1979). The increased free carbon dioxide associated with dredge activities tends to reduce the ph, making the gills of fishes and other biota more susceptible to pollutant-laden particles in suspension (Darnell 1976). Generally, pollutants are more rapidly assimilated in deposit feeders than in suspension feeders, with concentrations of heavy metals increasing up to three times in affected macroinvertebrates (Rosenberg 1977).

In some areas the construction of drainage canals and levees will reduce freshwater inflow into estuaries and resultant increased saltwater intrusion may eventually eliminate the broad mixing zone important as nursery grounds for juvenile fishes, shrimp, crabs, etc. (Darnell 1976). These canals and levees may also serve as migrational barriers to terrestrial and semiterrestrial fauna that utilize marshes.

5.4.1.2.3 Ecology. Production and food-web relationships in wetlands and their downstream dependent systems are governed, in part, by regional climatic conditions and hydrologic properties of the watersheds in which they are situated. Such factors determine nutrient and energy transport, gradients of physio-chemical variables, and timing of the system response. Construction of the proposed projects and resulting probable

short-term impacts within construction right-of-way to local habitats and hydrology will disrupt food-webs and microhabitat distribution as described in Section 4.2.2.3 under saline marsh.

The role of wetlands in mediating the origin, form, and timing of production, and the trophodynamic process of wetlands and associated downstream systems are not fully understood, especially with respect to regulatory mechanisms and temporal progressions of community organization (Livingston and Loucks 1978). Systems methods are available and necessary to define and quantify these relationships but it is nearly impossible to forecast the long-term consequences of various forms of human intervention.

5.4.1.2.4 Areas of Special Concern. Due to accelerated erosional processes all coastal wetlands, their functions and importance can be considered areas of special concern. It is not anticipated that salt marsh wetlands will be severely impacted, due to the small amount of those wetlands which will be impacted by project construction. Also, no rookeries nor habitats of endangered species will be impacted.

5.4.1.3 Social.

5.4.1.3.1 Land Uses. No impact.

5.4.1.3.2 Cultural Features. No impact.

5.4.1.3.3 Other Programs in the Area. No impact.

5.4.1.4 Economics. No impact.

5.4.2 Brackish Marsh.

5.4.2.1 Physical.

5.4.2.1.1 Meteorological and Climatological. Probable impacts are similar to those described in Section 5.3.1.1.1 under saline marsh.

5.4.2.1.2 Topological. Probable impacts to local brackish marsh topology are similar to those described for saline marsh in Section 5.4.1.1.2.

5.4.2.1.3 Geological. It is not anticipated that existing brackish marsh geology will suffer adverse impacts resulting from project construction.

5.4.2.1.4 Soils. Brackish marsh soils as described in Section 4.3.1.4 will experience impacts similar to those described for saline soils in Section 5.4.1.1.4.

5.4.2.1.5 Hydrological. Probable impacts to brackish marsh hydrology are similar to those described for saline marsh in Section 5.3.1.1.5.

5.4.2.1.6 Water Quality. Local water quality will be impacted by turbidity, suspended solids, sedimentation and associated physical and chemical modifications as described for saline marsh in Section 5.4.1.1.6.

5.4.2.1.7 Air Quality. Local air quality will be impacted as described in Section 5.3.1.1.7.

5.4.2.2 Biological.

5.4.2.2.1 Flora. Probable impacts to brackish marsh flora within construction rights-of-way and project boundaries will be similar to those probable impacts for saline marsh described in Section 5.4.1.2.1.

5.4.2.2.2 Fauna. Probable impacts to brackish marsh fauna will be similar to those impacts described for saline marsh in Section 5.4.1.2.2.

5.4.2.2.3 Ecology. Probable impacts to brackish marsh ecology are similar to those in Section 5.4.1.2.3 under saline marsh.

5.4.2.2.4 Areas of Special Concern. Brackish marsh areas of special concern are similar to those described for saline marshlands in Section 5.4.1.2.4. This marsh type is experiencing higher erosional rates than saline marsh and is being converted to open water areas. In some cases, brackish marsh areas within proposed project boundaries will be protected from probable loss due to erosional processes.

5.4.2.3 Social.

5.4.2.3.1 Land Uses. Brackish marsh land use will not be impacted by proposed project construction.

5.4.2.3.2 Cultural Features. It is not anticipated that brackish marsh cultural features will be impacted.

5.4.2.3.3 Other Programs in the Area. No impact.

5.4.2.4 Economics. Existing brackish marsh economics will not be impacted by proposed project construction.

5.4.3 Intermediate marsh.

5.4.3.1 Physical.

5.4.3.1.1 Meteorological and Climatological. Probable impacts to local climatic conditions resulting from proposed project construction are similar to those described for saline marsh in Section 5.3.1.1.1.

5.4.3.1.2 Topological. Probable impacts to local topology resulting from proposed project construction are similar to those described in Section 5.4.1.1.2 for saline marsh.

5.4.3.1.3 Geological. No impact.

5.4.3.1.4 Soils. Intermediate soils will suffer similar probable impacts as described in Section 5.4.1.1.4 for saline marsh.

5.4.3.1.5 Hydrological. Probable impacts to local hydrology are similar to those described in Section 5.3.1.1.5 for saline marsh.

5.4.3.1.6 Water Quality. Probable impacts to local water quality will be similar to those described in Section 5.4.1.1.6 for saline marsh.

5.4.3.1.7 Air Quality. Probable impacts to local air quality are similar to those described in Section 5.3.1.1.7 for saline marsh.

5.4.3.2 Biological.

5.4.3.2.1 Flora. Probable impacts to local flora are similar to those described in Section 5.4.1.2.1 for saline marsh.

5.4.3.2.2 Fauna. Probable impacts to local fauna are similar to those described in Section 5.4.1.2.2 for saline marsh.

5.4.3.2.3 Ecology. Probable impacts are similar to those described in Section 5.4.1.2.3 under saline marsh.

5.4.3.2.4 Areas of Special Concern. Impacts to intermediate marsh are similar to those described in Section 5.4.2.2.4 for brackish marsh. Like brackish marsh, in some cases intermediate marsh areas within proposed project boundaries will be protected from probable loss due to erosional processes.

5.4.3.3 Social.

5.4.3.3.1 Land Uses. Minor impacts to existing land use will result from some loss of intermediate habitat within construction right-of-way.

5.4.3.3.2 Cultural Features. No impact.

5.4.3.3.3 Other Programs in the Area. No impacts.

5.4.3.4 Economics. Intermediate marsh economics will not be impacted by the wetland/non-wetland alternative.

5.4.4 Freshwater Marsh.

5.4.4.1 Physical.

5.4.4.1.1 Meteorological and Climatological. Probable impacts to local climatic conditions resulting from project construction are similar to those described in Section 5.3.1.1.1 for saline marsh.

5.4.4.1.2 Topological. Local topology of freshwater marsh is impacted by local changes in hydrology. High energy hydrologic regime will carry much of the production out of the marsh (Mason and Bryant 1975), but there are at least two feedback loops that modify this response. Vegetation will no longer act as a silt trap for sheetflows from the ridges. Normally, this tends to increase the sedimentation rate and raise the elevation of the marsh. Also, as the marsh elevation would increase, the frequency and depth of flooding would decrease, resulting in less exportation of organic production with more deposition and increased elevation.

5.4.4.1.3 Geological. No impact.

5.4.4.1.4 Soils. Fresh marsh soils will be impacted in a manner similar to the description in 5.4.1.1.4 for saline soils.

5.4.4.1.5 Hydrological. Probable impacts to local hydrology are similar to those described in Section 5.3.1.1.5 for saline marsh.

5.4.4.1.6 Water Quality. Probable impacts to local water quality are similar to those described in Section 5.4.1.1.6 for saline marsh.

5.4.4.1.7 Air Quality. Probable impacts to local air quality are similar to those described in Section 5.3.1.1.7 for saline marsh.

5.4.4.2 Biological.

5.4.4.2.1 Flora. Probable impacts to local flora are similar to those described in Section 5.4.1.2.1 for saline marsh. Local impacts on hydrology could impact spatial heterogeneity, which thus influences species richness. The hydrologic regime can contribute to elevational and substrate differences, which are a chief source of species diversity in wetlands (Hinde 1954). As rising waters crest over stream banks, current velocity is reduced, resulting in a gradient of elevation and sediment grain size. This results in typical plant zonation, with different species occurring at different elevations. Diversity generally seems to increase with elevation and therefore is a function of flooding duration and depth. Data from Heinselman (1970) indicates that plant species richness increases with increasing water velocity. Thus, the hydrologic regime can lead to either uniformity or to diversity, depending on the regime of a specific wetland landscape.

5.4.4.2.2 Fauna. Probable adverse impacts to local fauna will be similar to those described in Section 5.4.1.2.2 for saline marsh.

5.4.4.2.3 Ecology. Probable impacts to local ecology are similar to those described in Section 5.4.1.2.3 for saline marsh.

5.4.4.2.4 Areas of Special Concern. Impacts to fresh marsh are similar to those described in Section 5.4.2.2.4 for brackish marsh. In some cases, fresh marsh areas within proposed project boundaries will be protected from probable loss due to erosional processes.

5.4.4.3 Social.

5.4.4.3.1 Land Uses. Minor impacts to existing land use will result from some loss of fresh marsh habitat within construction rights-of-way.

5.4.4.3.2 Cultural Features. No impact.

5.4.4.3.3 Other Programs in the Area. No impact.

5.4.4.4 Economics. Fresh marsh economics will not be impacted by the wetland/non-wetland alternative.

5.4.5 Cypress-Tupelogum Swamp.

5.4.5.1 Physical.

5.4.5.1.1 Meteorological and Climatological. Probable impacts to local climatic conditions resulting from project construction are similar to those described in Section 5.3.1.1.1 for saline marsh.

5.4.5.1.2 Topological. Elevational changes of natural ground elevations will occur within construction rights-of-way resulting from canal excavation and levee construction.

5.4.5.1.3 Geological. No impact.

5.4.5.1.4 Soils. Probable impacts to swamp soils are similar to those described in Section 5.4.1.1.4 for saline marsh.

5.4.5.1.5 Hydrological. Probable impacts to local hydrology are similar to those described in Section 5.3.1.1.5 for saline marsh.

5.4.5.1.6 Water Quality. Probable impacts to local water quality are similar to those described in Section 5.4.1.1.6 for saline marsh. Also, possible eutrophic conditions may exist, resulting from point source discharges directly into receiving bodies of water.

5.4.5.1.7 Air Quality. Probable impacts to local air quality are similar to those described in Section 5.3.1.1.7.

5.4.5.2 Biological.

5.4.5.2.1 Flora. Probable impacts to local flora are similar to those described in Section 5.4.1.2.1 for saline marsh. Also, probable impacts which could occur are similar to those found by Conner, *et al.* (1981) in a study of three Louisiana swamp sites with different flooding regimes. They found that interruption of the cyclic overland flow of water in a permanently flooded area brought about several sequential changes. Species tolerant to constant flooding such as ash began dying out, while the recruitment of the tolerant species (bald cypress and water tupelo) was prevented by the constantly flooded forest floor. As trees died the canopy opened. The opening of the canopy, together with the abundance of decaying logs and stumps, made possible the invasion of shrubs such as buttonbush. Penetration of light to the standing water on the forest floor facilitated a luxuriant growth of floating aquatic species such as water hyacinths, duckweeds, and water fern.

5.4.5.2.2 Fauna. Probable impacts to local fauna are similar to those described in Section 5.4.1.2.2 for saline marsh.

5.4.5.2.3 Ecology. Probable impacts to local ecology are similar to those described in Section 5.4.1.2.3 for saline marsh.

5.4.5.2.4 Areas of Special Concern. Impacts to swamp habitat are similar to those described in Section 5.4.2.2.4 for brackish marsh. In some cases, swamp areas within proposed project boundaries will be protected from probable loss due to erosional processes.

5.4.5.3 Social.

5.4.5.3.1 Land Uses. Minor impacts to existing land use will result from some loss of swamp habitat within construction rights-of-way.

5.4.5.3.2 Cultural Features. No impact.

5.4.5.3.3 Other Programs in the Area. No impact.

5.4.5.4 Economics. Economic benefits of saline marsh will not be impacted by the proposed project.

5.4.6 Wet Bottomland Hardwood Forest.

5.4.6.1 Physical.

5.4.6.1.1 Meteorological and Climatological. Probable impacts to local climate conditions resulting from project construction are similar to those described in Section 5.3.1.1.1 under saline marsh.

5.4.6.1.2 Topological. No impact.

5.4.6.1.3 Geological. No impact.

5.4.6.1.4 Soils. Probable impacts to local soils will be similar to those described in Section 5.4.1.1.4 under saline marsh.

5.4.6.1.5 Hydrological. Probable impacts to local hydrology are similar to those described in Section 5.3.1.1.5 under saline marsh.

5.4.6.1.6 Water Quality. Probable impacts to local water quality are similar to those described in Section 5.4.1.1.6 under saline marsh.

5.4.6.1.7 Air Quality. Probable impacts to local air quality are similar to those described in Section 5.3.1.1.7 under saline marsh.

5.4.6.2 Biological.

5.4.6.2.1 Flora. Probable impacts to local flora are similar to those described in Section 5.4.1.2.1 under saline marsh. Diminished flooding creates a potential within the flood-plain environment for change in forest-species composition. This potential for change is a reflection of a diminished favorability of the environment for some species and the emergence of a more favorable environment for other species in the habitat or new species which can become established.

Results of decreased flooding are not so dramatic or obvious as stress due to increase in flooding. Burgess *et al.* (1973) indicate that flood reduction has led to decreased tree growth and decline in tree reproduction. Phipps *et al.* (1979) examined growth responses of loblolly pine in an area of near-land-surface water table where water levels had been lowered slightly by ditching. They found rapid increases in growth rate following ditching and then a gradual, several-year decrease (of growth rates) to preditching rates. The slight lowering of the near-surface water table allowed what they termed "root release", resulting in a growth response analogous to that typically associated with crown release following lumbering.

5.4.6.2.2 Fauna. Probable impacts to local fauna are similar to those described in Section 5.4.1.2.2 under saline marsh. The constantly fluctuating water levels influence the opportunity for a variety of species to exploit the environment for food. The dynamic nature of water fluctuations may at times cause dramatic changes in foraging conditions on a specific site in less than one day (Fredrickson 1978).

5.4.6.2.3 Ecology. Probable impacts to local ecology are similar to those described in Section 5.4.1.2.3 for saline marsh.

5.4.6.2.4 Areas of Special Concern. Bottomland hardwoods like other wetland types are being impacted as described in Section 5.4.1.2.4 for saline marsh. Much of these wetlands have been cleared in the past for agricultural purposes. Today these wetlands are still being cleared for residential, commercial, and industrial development. The continued loss of these wetlands, their associated values, and their contribution to Terrebonne Parish habitat diversity should be given special concern.

5.4.6.3 Social.

5.4.6.3.1 Land Uses. Minor impacts will result from loss of hardwood habitat within construction rights-of-way. Greater impacts may result from the possibility of clearing those unavoidably encompassed hardwoods once under pump within proposed project boundaries.

5.4.6.3.2 Cultural Features. No impact.

5.4.6.3.3 Other Programs in the Area. No impact.

5.4.6.4 Economics. Economic returns from bottomland hardwoods will be slightly impacted due to the loss of this habitat type.

5.4.7 Dry Bottomland Hardwood Forest. Does not exist in Terrebonne Parish. No impact.

5.4.8 Other Upland Areas.

5.4.8.1 Physical.

5.4.8.1.1 Meteorological and Climatological. No impact.

5.4.8.1.2 Topological. No impact.

5.4.8.1.3 Geological. No impact.

5.4.8.1.4 Soils. No impact.

5.4.8.1.5 Hydrological. Runoff from upland areas will be directed to collection canals and mechanically removed from the area.

5.4.8.1.6 Water Quality. No impact.

5.4.8.1.7 Air Quality. No impact.

5.4.8.2 Biological.

5.4.8.2.1 Flora. No impact.

5.4.8.2.2 Fauna. No impact.

5.4.8.2.3 Ecology. No impact.

5.4.8.2.4 Areas of Special Concern. No impact.

5.4.8.3 Social.

5.4.8.3.1 Land Uses. Marginal areas along the backslopes of the natural ridges will probably become more attractive to development once the area is under forced drainage.

5.4.8.3.2 Cultural Features. No impact.

5.4.8.3.3 Other Programs in the Area. No impact.

5.4.8.4 Economics. Probable impacts to local economics are similar to those described in Section 5.3.8.4.

5.5 Effects of Wetland Alternative.

5.5.1 Saline Marsh.

5.5.1.1 Physical.

5.5.1.1.1 Meteorological and Climatological. Probable impacts to local climate conditions are similar to those described in Section 5.3.1.1.1 under saline marsh.

5.5.1.1.2 Topological. Probable impacts to local topology are similar to those described in Section 5.4.1.1.2 under saline marsh. Also, prolonged drying and oxidation of impounded marsh soils will result in an appreciable increase in subsidence rates. However, over long periods there may be a natural rise in elevation resulting from plant material accumulations.

5.5.1.1.3 Geological. See Section 5.5.1.1.2.

5.5.1.1.4 Soils. Probable impacts to saline marsh soils resulting from construction activities are similar to those described in Section 5.4.1.1.4 under saline marsh. Saline soil characteristics will probably change due to vegetational changes resulting from water quality changes and groundwater drawdown levels.

5.5.1.1.5 Hydrological. Probable impacts to local hydrology are similar to those described in Section 5.3.1.1.5 under saline marsh. Also, impounded saline wetlands within project boundaries will no longer be subject to tidal flows. These impounded areas can also alter existing flow patterns of adjacent habitat.

5.5.1.1.6 Water Quality. Probable impacts to local water quality resulting from proposed construction activities are similar to those described in Section 5.4.1.1.6 under saline marsh. Salinity levels within proposed project boundaries will decrease with a probable gradual change to freshwater marsh or fresh open water areas.

5.5.1.1.7 Air Quality. Probable impacts to local air quality are similar to those described in Section 5.3.1.1.7 under saline marsh.

5.5.1.2 Biological.

5.5.1.2.1 Flora. Probable impacts to local flora resulting from project construction are similar to those described in Section 5.4.1.2.1.

Saline marsh vegetation encompassed within project boundaries will probably be gradually replaced by plant species indigenous to fresher habitats and drier soil conditions.

5.5.1.2.2 Fauna. Probable impacts to local fauna resulting from proposed construction activities are similar to those described in Section 5.4.1.2.2 under saline marsh. Species indigenous to saline marsh within project boundaries may suffer a future loss of habitat resulting from a changing vegetation regime as described above. Levee construction will provide upland habitat within a wetland area, increasing habitat diversity. The proposed levees will act as barriers and may impact aquatic organisms by reducing or eliminating export of detritus and associated nutrients to adjacent habitats.

5.5.1.2.3 Ecology. Probable impacts to local ecology are similar to those described in Section 5.4.1.2.3 under saline marsh.

5.5.1.2.4 Areas of Special Concern. Probable impacts to areas of special concern are similar to those described in Section 5.4.1.2.4 under saline marsh.

5.5.1.3 Social.

5.5.1.3.1 Land Uses. Saline marsh areas within project levees will probably gradually convert to fresher and/or drier habitats. Terrestrial and aquatic species utilizing saline marsh for all or part of their life cycles will be adversely impacted by proposed project construction. Drier conditions may result in utilization of marsh areas for cattle grazing or other man-related uses.

5.5.1.3.2 Cultural Features. No impact.

5.5.1.3.3 Other Programs in the Area. No impact.

5.5.1.4 Economics. Probable salt marsh conversion and the loss of its associated productivity may adversely impact salt marsh economics. Economic impacts to salt marsh are expected to be minor, resulting from the minimal area of salt marsh encompassed within project boundaries.

5.5.2 Brackish Marsh.

5.5.2.1 Physical.

5.5.2.1.1 Meteorological and Climatological. Probable impacts to local climate are similar to those described in Section 5.3.1.1.1 under saline marsh.

5.5.2.1.2 Topological. Probable impacts to local topology are similar to those described in Section 5.5.1.1.2 under saline marsh.

5.5.2.1.3 Geological. No impact.

5.5.2.1.4 Soils. Probable impacts to brackish marsh soils are similar to those described in Section 5.5.1.1.4 under saline marsh.

5.5.2.1.5 Hydrological. Probable impacts to local hydrology are similar to those described in Section 5.5.1.1.5 under saline marsh.

5.5.2.1.6 Water Quality. Probable impacts to local water quality are similar to those described in Section 5.5.1.1.6 under saline marsh.

5.5.2.1.7 Air Quality. Probable impacts to existing air quality will be localized and similar to those described in Section 5.3.1.1.7 under saline marsh.

5.5.2.2 Biological.

5.5.2.2.1 Flora. Probable impacts to brackish marsh flora within project levees are similar to those described in Section 5.5.1.2.1 under saline marsh.

5.5.2.2.2 Fauna. Probable impacts to local brackish marsh fauna are similar to those described in Section 5.5.1.2.2 under saline marsh.

5.5.2.2.3 Ecology. Probable impacts to local ecology of brackish marsh within project boundaries are similar to those described in Section 5.5.1.2.3 under saline marsh.

5.5.2.2.4 Areas of Special Concern. Probable impacts to brackish marsh areas of special concern are similar to those described in Section 5.4.1.2.4 under saline marsh.

5.5.2.3 Social.

5.5.2.3.1 Land Uses. Probable impacts to brackish marsh land use within project boundaries are similar to those described in Section 5.5.1.3.1 under saline marsh.

5.5.2.3.2 Cultural Features. No impact.

5.5.2.3.3 Other Programs in the Area. No impact.

5.5.2.4 Economics. Probable brackish marsh conversion and the loss of its associated productivity may adversely impact brackish marsh economics.

5.5.3 Intermediate Marsh.

5.5.3.1 Physical.

5.5.3.1.1 Meteorological and Climatological. Probable impacts to local climate are similar to those described in Section 5.3.1.1.1 under saline marsh.

5.5.3.1.2 Topological. Probable impacts to intermediate marsh topology within project boundaries are similar to those described in Section 5.5.1.1.2 under saline marsh.

5.5.3.1.3 Geological. No impact.

5.5.3.1.4 Soils. Probable impacts to intermediate marsh soils are similar to those described in Section 5.5.1.1.4 under saline marsh.

5.5.3.1.5 Hydrological. Probable impacts to existing hydrology patterns within proposed project boundaries are similar to those described in Section 5.5.1.1.5 under saline marsh.

5.5.3.1.6 Water Quality. Probable impacts to intermediate marsh water quality are similar to those described in Section 5.5.1.1.6. under saline marsh.

5.5.3.1.7 Air Quality. Probable impacts to local air quality are similar to those described in Section 5.3.1.1.7 under saline marsh.

5.5.3.2 Biological.

5.5.3.2.1 Flora. Probable impacts to intermediate marsh flora in the proposed project area are similar to those described in Section 5.5.1.2.1 under saline marsh.

5.5.3.2.2 Fauna. Probable impacts to local intermediate marsh fauna are similar to those described in Section 5.5.1.2.2 under saline marsh.

5.5.3.2.3 Ecology. Probable impacts to intermediate marsh ecology are similar to those described in Section 5.4.1.2.3 under saline marsh.

5.5.3.2.4 Areas of Special Concern. Probable impacts to intermediate marsh areas of special concern are similar to those described in Section 5.4.1.2.4 under saline marsh.

5.5.3.3 Social.

5.5.3.3.1 Land Uses. Probable impacts to local intermediate marsh are similar to those described in Section 5.5.1.3.1 under saline marsh.

5.5.3.3.2 Cultural Features. No impact.

5.5.3.3.3 Other Programs in the Area. No impact.

5.5.3.4 Economics. Probable intermediate marsh conversion and the loss of its associated productivity may adversely impact intermediate marsh economics.

5.5.4 Freshwater Marsh.

5.5.4.1 Physical.

5.5.4.1.1 Meteorological and Climatological. Probable impacts to local climate conditions are similar to those described in Section 5.3.1.1.1 under saline marsh.

5.5.4.1.2 Topological. Probable impacts to local topology are similar to those described in Section 5.4.1.1.2 under saline marsh. Subsidence potential is greatest in this habitat due to the high concentration of organic material which is subject to shrinkage and oxidation as a result of water level drawdown.

5.5.4.1.3 Geological. No impact.

5.5.4.1.4 Soils. Probable impacts to fresh marsh soils resulting from construction activities are similar to those described in Section 5.4.1.1.4 under saline marsh. Potential for shrinkage of existing soil profiles within project boundaries are due to the high concentration of organic matter subject to oxidation resulting from water level drawdown.

5.5.4.1.5 Hydrological. Probable impacts to local hydrology are similar to those described in Section 5.5.1.1.5 under saline marsh.

5.5.4.1.6 Water Quality. Probable impacts to local water quality resulting from proposed construction activities are similar to those described in Section 5.4.1.1.6 under saline marsh.

5.5.4.1.7 Air Quality. Probable impacts to local air quality are similar to those described in Section 5.3.1.1.7 under saline marsh.

5.5.4.2 Biological.

5.5.4.2.1 Flora. Probable impacts to local flora resulting from construction activities are similar to those described in Section 5.4.1.2.1. Under pumping conditions, vegetative species may change to a more terrestrial shrub type because of drying soil conditions.

5.5.4.2.2 Fauna. Probable impacts to local fauna resulting from proposed construction activities are similar to those described in Section 5.4.1.2.2 under saline marsh. Species indigenous to fresh marsh within project boundaries may suffer a future loss of habitat because of a changing vegetation regime as described above. Levee construction will provide upland habitat within a wetland area, increasing habitat diversity. The proposed levees will act as barriers and may impact aquatic organisms by reducing or eliminating export of detritus and associated nutrients to adjacent habitats.

5.5.4.2.3 Ecology. Probable impacts to local ecology are similar to those described in Section 5.4.1.2.3 under saline marsh.

5.5.4.2.4 Areas of Special Concern. Probable impacts to areas of special concern are similar to those described in Section 5.4.1.2.4 under saline marsh.

5.5.4.3 Social.

5.5.4.3.1 Land Uses. Unavoidably included fresh marsh areas within project levees will probably gradually convert to drier conditions supportive of shrub and woody vegetation. Terrestrial and aquatic species utilizing fresh marsh for all or part of their life cycles will be adversely impacted by the proposed project and eventual change of habitat. Drier conditions may result in utilizing these marsh areas for cattle grazing or other man-related uses.

5.5.4.3.2 Cultural Features. No impact.

5.5.4.3.3 Other Programs in the Area. No impact.

5.5.4.4 Economics. Probable fresh marsh conversion and the loss of its associated productivity may adversely impact fresh marsh economics.

5.5.5 Cypress-Tupelogum Swamp.

5.5.5.1 Physical.

5.5.5.1.1 Meteorological and Climatological. Probable impacts to local climate conditions are similar to those described in Section 5.3.1.1.1 under saline marsh.

5.5.5.1.2 Topological. Probable impacts to local topology are similar to those described in Section 5.4.1.1.2 under saline marsh. Also, prolonged drying and oxidation of impounded swamp soils will result in an appreciable increase in subsidence rates.

5.5.5.1.3 Geological. No impact.

5.5.5.1.4 Soils. Probable impacts to swamp soils resulting from construction activities are similar to those described in Section 5.4.1.1.4 under saline marsh.

5.5.5.1.5 Hydrological. Probable impacts to local hydrology are similar to those described in Section 5.5.1.1.5 under saline marsh.

5.5.5.1.6 Water Quality. Probable impacts to local water quality from construction activities are similar to those described in Section 5.4.1.1.6 under saline marsh.

5.5.5.1.7 Air Quality. Probable impacts to local air quality are similar to those described in Section 5.3.1.1.7 under saline marsh.

5.5.5.2 Biological.

5.5.5.2.1 Flora. Probable impacts to local flora resulting from project construction activities are similar to those described in Section 5.4.1.2.1 under saline marsh. The probable drying of some swamp areas within project boundaries may result in a change from a bald cypress-water tupelo community to a maple-ash community typical of wet bottomlands.

5.5.5.2.2 Fauna. Probable impacts to local fauna resulting from proposed construction activities are similar to those described in Section 5.4.1.2.2 under saline marsh. Species indigenous to cypress-tupelo swamps within project boundaries may suffer a future loss of habitat resulting from a changing vegetation regime as described above.

5.5.5.2.3 Ecology. Probable impacts to local ecology are similar to those described in Section 5.4.1.2.3 under saline marsh.

5.5.5.2.4 Areas of Special Concern. Probable impacts to areas of special concern are similar to those described in Section 5.4.1.2.4 under saline marsh.

5.5.5.3 Social.

5.5.5.3.1 Land Uses. Unavoidably encompassed cypress-tupelo swamp areas within project boundaries will probably gradually convert to drier bottomland hardwoods. Terrestrial and aquatic species utilizing cypress-tupelo swamp for all or part of their life cycles will be adversely impacted by habitat loss or conversion resulting from project construction. Drier conditions may result in utilizing the swamp areas for man-related uses.

5.5.5.3.2 Cultural Features. No impact.

5.5.5.3.3 Other Programs in the Area. No impact.

5.5.5.4 Economics. Probable cypress-tupelo swamp conversion and the loss of its associated productivity may adversely impact swamp economics.

5.5.6 Wet Bottomland Hardwood Forest.

5.5.6.1 Physical.

5.5.6.1.1 Meteorological and Climatological. Probable impacts to local climate conditions are similar to those described in Section 5.3.1.1.1 under saline marsh.

5.5.6.1.2 Topological. Probable impacts to local topology are similar to those described in Section 5.4.1.1.2 under saline marsh.

5.5.6.1.3 Geological. No impact.

5.5.6.1.4 Soils. Probable impacts to wet bottomland hardwood soils resulting from construction activities are similar to those described in Section 5.4.1.1.4 under saline marsh.

5.5.6.1.5 Hydrological. Probable impacts to local hydrology are similar to those described in Section 5.5.1.1.5 under saline marsh.

5.5.6.1.6 Water Quality. Probable impacts to local water quality resulting from proposed construction activities are similar to those described in Section 5.4.1.1.6 under saline marsh.

5.5.6.1.7 Air Quality. Probable impacts to local air quality are similar to those described in Section 5.3.1.1.7 under saline marsh.

5.5.6.2 Biological.

5.5.6.2.1 Flora. Probable impacts to local flora resulting from project construction are similar to those described in Sections 5.4.1.2.1 under saline marsh. Flood-tolerant species may be replaced by less tolerant species. Also, hardwood areas within project boundaries will be subjected to increased pressure for development purposes.

5.5.6.2.2 Fauna. Probable impacts to local fauna resulting from proposed construction activities are similar to those described in Section 5.4.1.2.2 under saline marsh. Species indigenous to wet bottomland hardwoods within project boundaries may suffer a future loss of habitat resulting from development activities. Levee construction will provide

upland habitat within a wetland area, resulting in increased habitat diversity.

5.5.6.2.3 Ecology. Probable impacts to local ecology are similar to those described in Section 5.4.1.2.3 under saline marsh.

5.5.6.2.4 Areas of Special Concern. Probable impacts to bottomland hardwood areas of special concern are similar to those described in Section 5.4.1.2.4 under saline marsh.

5.5.6.3 Social.

5.5.6.3.1 Land Uses. Marginal wet bottomland hardwoods now being utilized by various species of wildlife and included within proposed project boundaries may ultimately be cleared for continuing residential, commercial and industrial expansion.

5.5.6.3.2 Cultural Features. No impact.

5.5.6.3.3 Other Programs in the Area. No impact.

5.5.6.4 Economics. Probable wet bottomland hardwood conversion to residential, commercial and industrial developments and loss of its associated harvestable productivity may impact wet bottomland hardwood economics.

5.5.7 Dry Bottomland Hardwood Forest.

This habitat type basically no longer exists within Terrebonne Parish. Therefore, this alternative has no impact.

5.5.8 Other Upland Areas.

5.5.8.1 Physical.

5.5.8.1.1 Meteorological and Climatological. No impact.

5.5.8.1.2 Topological. Some increases in subsidence rates may result from existing groundwater level drawdown.

5.5.8.1.3 Geological. No impact.

5.5.8.1.4 Soils. No impact

5.5.8.1.5 Hydrological. Natural flows will be altered and directed to collection canals.

5.5.8.1.6 Water Quality. No impact.

5.5.8.1.7 Air Quality. Probable impacts to existing air quality will be localized and similar to those described in Section 5.3.1.1.7 under saline marsh.

5.5.8.2 Biological.

5.5.8.2.1 Flora. No impact.

5.5.8.2.2 Fauna. No impact.

5.5.8.2.3 Ecology. No impact.

5.5.8.2.4 Areas of Special Concern. No impact.

5.5.8.3 Social.

5.5.8.3.1 Land Uses. No impact.

5.5.8.3.2 Cultural Features. No impact.

5.5.8.3.3 Other Programs in the Area. No impact.

5.5.8.4 Economics. Probable impacts to local economics are similar to those described in Section 5.3.8.4.

6.0 List of Preparers

LIST OF PREPARERS			Role in Preparing FIS
Name	Expertise/Discipline	Experience	Hydrology
Charles E. Adams	Geological Engineering Physical Oceanography	12 years research scientist, coastal studies 2 years professor of Oceanography, LSU	Hydrology
Robert H. Baumann	Physical Geography Botany	8 years research associate, Center for Wetland Resources 2 years research assistant, Dept. of Geography, LSU 4 years mapping wetland habitats	Flora, Fauna, Ecology Cultural Resources, Environmental Consequences
Robert H. Chabreck	Botany, Wildlife Management	6 years research, La. Wildlife Fisheries Commission 5 years research, U.S. Fish and Wildlife Service 10 years professor and research, School of Forestry and Wildlife Management	Flora, Fauna, Ecology
Robert H. Cunningham	Geography, Geology Physical Geography	6 years research associate, coordinator-hydrographic surveys, hydromic models, turbidity studies, freshwater diversion impacts, tide and water level analysis, water budget modeling and evapotranspiration studies	Hydrology
Thomas C. Davidson	Specialist in Tropical and Subtropical Wetlands	16 years professor of botany and ecology 8 years research in agricultural development of tropical wetlands 3 years specialist in tropical agriculture, Dept. of Agriculture 3 years in regulatory functions, and environmental documentation, Corps of Engineers	U.S. Army Corps of Engineers Coordinator
Ronnie W. Duke	Wildlife Management, Forestry Environmental Analysis	6 years as environmental analyst, preparation of environmental impact statements and assessments	Alternatives, Affected Environment, Environmental Consequences, Coordinator between consultant and Corps of Engineers
Paul T. Henslee	Environmental Resources	9 years experience in environmental resource planning, 2 years experience in control and management of environmental assessments and impact statements	Water Quality

LIST OF PREPARERS (cont'd)

Name	Expertise/Discipline	Experience	Role in Preparing EIS
Christopher J. Ingram	Biology, Wildlife Biology	4 years experience in analysis of aquatic and terrestrial resources for numerous large-scale environmental projects	Water Quality
Mrs. Claire Joller	English/Journalism	6 years teaching english and journalism 2 1/2 years editor of Terrebonne Magazine 5 years experience as technical writer and researcher at T. Baker Smith and Son, Inc.	Economics, Editor
William G. McIntire	Coastal Morphology Coastal Oceanography Cultural Resources	32 years experience teaching and research Director, Coastal Studies Institute, LSU Assoc. Dir., Center for Wetland Resources, LSU conducted coastal morphodynamic research here and abroad Assisted and organized several coastal conferences, LSU 3 years involvement in coastal zone management - northern Gulf of Mexico Prof. Emeritus of Geography, Anthropology, and Marine Sciences - LSU Assoc. Dean Emeritus, Center for Wetland Resources, LSU	Topology, Geology, Cultural Resources, Environmental Consequences
Mrs. Flora Chu Wang	Civil Engineering; Systems Analysis in Water Resources Planning and Management; Hydrologic, Hydraulics, and Hydrodynamics Computer Modeling; Economic, Ecologic and Energetic Analysis; Estuarine Hydrodynamics; Deltaic Processes, and Coastal Oceanography	2 year associate professor, Dept. of Marine Sciences, Center for Wetland Resources, LSU 6 years research scientist, Univ. of Florida 1 year consultant, Coastal and Oceanographic Engineering Dept., Univ. of Florida 4 years systems engineer and staff member, computer division, The Ralph M. Parsons Company 4 years research in water resources, Harvard Univ. 4 years research assistant, Stanford Univ. 1 year research assistant, Univ. of Utah	Hydrology

7.0 Public Involvement.

Official public involvement in contributing to the EIS process began with a scoping meeting held on Thursday, 26 February, 1981 in Houma, Louisiana. Citizens' input into the EIS at the scoping meeting was documented and categorized into groups forming the scoping document, a basis and guide for EIS preparation.

Public involvement has continued throughout the EIS preparation with Citizens Advisory Committee input. Participants on the committee have had the opportunity to review and comment on EIS material before inclusion in the Draft Terrebonne Parish-Wide Environmental Impact Statement.

8.0 List of Organizations from whom comments are requested.

Federal

Honorable Lindy Boggs, US Congresswoman
Honorable John B. Breaux, US Congressman
Honorable Jerry Huckaby, US Congressman
Honorable J. Bennett Johnston, US Congressman
Honorable Robert L. Livingston, US Congressman
Honorable Gillis W. Long, US Congressman
Honorable Russell B. Long, US Congressman
Honorable W. Henson Moore, US Congressman
Honorable Charles Roemer III, US Congressman
Honorable Wilbert Tausin II, US Congressman
Advisory Council on Historic Preservation, Lakewood, Colorado
Dept. of Health and Human Services, Washington, District of Columbia
Environmental Protection Agency, Administrator, Dallas, Texas
Environmental Protection Agency, Region VI, Dallas, Texas
Environmental Protection Agency, Region VI Permits Branch, Dallas, Texas
Heritage Conservation & Recreation Service, Atlanta, Georgia
Federal Emergency Management Administration, Washington, District of
Columbia
US Army Engineers, Shreveport Area Office, Shreveport, Louisiana
US Army Engineer Division, Vicksburg, Mississippi
US Dept. of Agriculture, State Conservationist, Soil Conservation
Service, Alexandria, Louisiana
US Department of Agriculture, Regional Forester, Regional 8
Forest Service, Atlanta, Georgia
US Dept. of Commerce, Area Supervisor, National Marine Fisheries
Service, Water Resource Division, Galveston, Texas
US Dept. of Commerce, Regional Director, National Marine Fisheries
Service, Southeast Region, St. Petersburg, Florida
US Dept. of Commerce, Office of the Deputy Secretary for Environmental
Affairs, Washington, District of Columbia
US Dept. of Commerce, National Oceanic & Atmospheric Administration, Office
of Ecology and Conservation, Washington, District of Columbia
US Dept. of Energy, Advisor on Environmental Quality, Washington, District
of Columbia
US Dept. of Energy, Director, Environmental Impact Division, Office of
Environmental Programs, Washington, District of Columbia
US Dept. of Health and Human Services, Regional Director, Public Health
Service, Region VI, Dallas, Texas
US Dept. of Health and Human Services, Water Resources Activity, Vector
Biology and Control Division, Atlanta, Georgia
US Dept. of Housing and Urban Development, Regional Administrator, Region VI
Fort Worth, Texas
US Dept. of Interior, Assistant Secretary for Program Development, and Budget,
Office of Environmental Project Review, Washington, District of Columbia
US Dept. of Interior, Office of the Secretary, Washington, District of
Columbia
US Dept. of Interior, Regional Director, National Park Service,
Santa Fe, New Mexico
US Dept of Interior, Regional Director, South Central Region,
Albuquerque, New Mexico

US Dept. of Transportation, Commander, Second Coast Guard District,
St. Louis, Missouri
US Dept. of Transportation, Division Engineer, Federal Highway
Administration, Baton Rouge, Louisiana
US Fish and Wildlife Service, Area Manager, Jackson, Mississippi
US Fish and Wildlife Service, Field Supervisor, Lafayette, Louisiana
US Fish and Wildlife Service, Field Supervisor, Vicksburg, Mississippi
US Fish and Wildlife Service, Regional Director, Atlanta, Georgia

State

Honorable Leon L. Borne, Jr., Louisiana Representative
Honorable Leonard J. Chabert, Louisiana Senator
Honorable Murray J. Hebert, Louisiana Representative
Honorable Anthony Guarisco, Jr., Louisiana Senator
Honorable Jessie P. Guidry, Louisiana Representative
Honorable Ron Landry, Louisiana Senator
Honorable John Siracusa, Louisiana Representative
Louisiana Air Control Commission, New Orleans, Louisiana
Louisiana Archaeological Survey & Antiquities, Baton Rouge, Louisiana
Curator of Anthropology, Dept. of Geography and Anthropology,
Louisiana State University, Baton Rouge, Louisiana
Louisiana Department of Justice, Environmental Section, New Orleans, Louisiana
Louisiana Department of Agriculture, Commissioner, Baton Rouge, Louisiana
Louisiana Department of Commerce, Secretary, Baton Rouge, Louisiana
Louisiana Department of Culture, Recreation, and Tourism, Division of
Archaeology & Historic Preservation, State Historic Preservation Officer,
Baton Rouge, Louisiana
Louisiana Department of Health & Human Resources, Office of Health Services
& Environmental Quality, New Orleans, Louisiana
Coastal Management Section, Louisiana Department of Natural Resources
Baton Rouge, Louisiana
Louisiana Department of Natural Resources, Division of State Lands,
Baton Rouge, Louisiana
Louisiana Department of Natural Resources, Office of Conservation,
Baton Rouge, Louisiana
Louisiana Department of Natural Resources, Office of Environmental Affairs,
Water Pollution Control Division, Baton Rouge, Louisiana
Louisiana Department of Natural Resources, Office of Forestry, Baton
Rouge, Louisiana
Louisiana Department of Transportation and Development, Lafayette, Louisiana
Louisiana Department of Transportation and Development, Office of Highways,
Baton Rouge, Louisiana
Louisiana Department of Transportation and Development, Office of Management
and Finance, Project Control Engineer, Baton Rouge, Louisiana
Louisiana Department of Transportation and Development, Office of Public
Works, Alexandria, Louisiana
Louisiana Department of Transportation and Development, Office of Public
Works, Baton Rouge, Louisiana
Louisiana Department of Wildlife and Fisheries, Environmental Section,
Baton Rouge, Louisiana
Louisiana Department of Wildlife and Fisheries, Refuge Division,
New Orleans, Louisiana

Louisiana Department of Wildlife and Fisheries, Secretary, New Orleans,
Louisiana
Louisiana Environmental Professionals Association, Metairie, Louisiana
Louisiana Environmental Society, Inc., Shreveport, Louisiana
The Joint Legislative Committee on Environmental Quality, Baton Rouge,
Louisiana
Louisiana Public Service Commission, Baton Rouge, Louisiana
Louisiana State Parks and Recreation Commission, Baton Rouge, Louisiana
Louisiana State Planning Office, Baton Rouge, Louisiana
Louisiana State Soil and Water Conservation Committee, Louisiana
State University, Baton Rouge, Louisiana
Nicholls State University, Director, Environmental Services, Thibodaux,
Louisiana
Office of the Attorney General, Baton Rouge, Louisiana
Office of Intergovernmental Relations, Office of the Governor,
Baton Rouge, Louisiana
Office of the Governor, Baton Rouge, Louisiana
Office of the Lieutenant Governor, Baton Rouge, Louisiana
University of New Orleans, Coordinator, Environmental Impact
Section, Department of Environmental Affairs, New Orleans, Louisiana

Local

Ascension Parish Police Jury, Donaldsonville, Louisiana
Assumption Parish Police Jury, Napoleonville, Louisiana
Calcasieu Parish Police Jury, Lake Charles, Louisiana
Cameron Parish Police Jury, Cameron, Louisiana
Iberia Parish Police Jury, New Iberia, Louisiana
Jefferson Parish Council, Gretna, Louisiana
Lafourche Parish Police Jury, Thibodaux, Louisiana
Livingston Parish Police Jury, Livingston, Louisiana
Plaquemines Parish Commission Council, Sulphur, Louisiana
St. Bernard Parish Police Jury, Chalmette, Louisiana
St. Charles Parish Council, Hahnville, Louisiana
St. James Parish Council, Convent, Louisiana
St. John the Baptist Parish Police Jury, LaPlace, Louisiana
St. Martin Parish Police Jury, St. Martinville, Louisiana
St. Mary's Parish Police Jury, Franklin, Louisiana
St. Tammany Parish Council, Covington, Louisiana
Tangipahoa Parish Police Jury, Amite, Louisiana
Terrebonne Parish Police Jury, Houma, Louisiana
Vermilion Parish Police Jury, Abbeville, Louisiana
Mayor, City of Houma, Houma, Louisiana
Mayor, City of Morgan City, Morgan City, Louisiana
Mayor, City of New Orleans, New Orleans, Louisiana
Mayor, City of Thibodaux, Thibodaux, Louisiana
American Shrimp Cannery Association, Dulac, Louisiana
Assumption Parish Planning Commission, Napoleonville, Louisiana
Atchafalaya Basin Levee District Board, Port Allen, Louisiana
Bayou Board of Realtors, Houma, Louisiana
Greater Lafourche Port Commission, Galliano, Louisiana
Home Builders Association of Terrebonne, Houma, Louisiana
Houma Indian Tribal Council, Dulac, Louisiana
Houma-Terrebonne Chamber of Commerce, Houma, Louisiana

Houma-Terrebonne Regional Planning Commission, Houma, Louisiana
Lafourche Parish Planning Commission, Thibodaux, Louisiana
Louisiana Oyster Growers Association, Houma, Louisiana
Louisiana Shrimpers Association, Lockport, Louisiana
Office of Intergovernmental Relations, Office of the Governor,
Baton Rouge, Louisiana
South Central Planning & Development Commission, Thibodaux, Louisiana
Teche Regional Clearinghouse, C/o South Central Planning and Division Center,
Thibodaux, Louisiana
Terrebonne Port Commission, Houma, Louisiana
Terrebonne Parish CZM Advisory Committee, Houma, Louisiana
Terrebonne Parish School Board, Houma, Louisiana
Tidewater Levee District, Galliano, Louisiana

Environmental

Concerned Citizens of Terrebonne Parish, Bourg, Louisiana
The Conservation Foundation, Washington, District of Columbia
Ecology Center of Louisiana, Inc., New Orleans, Louisiana
Environmental Defense Fund, New York, New York
Environmental Information Center, New York, New York
Environmental Professionals, Limited, Metairie, Louisiana
Heritage Conservation & Recreation Service, South Central Region,
Albuquerque, New Mexico
League of Women Voters of the US, Baton Rouge, Louisiana
Louisiana Biologists Association, Baton Rouge, Louisiana
Louisiana Wildlife Federation, Baton Rouge, Louisiana
Library, National Audubon Society, New York, New York
National Audubon Society, Southwestern Regional Office, Austin, Texas
National Sierra Club, Delta Chapter & New Orleans Group, New Orleans,
Louisiana
National Sierra Club, San Francisco, California
National Wildlife Federation, Washington, District of Columbia
Natural Resources Defense Council, Washington, District of Columbia
Orleans Audubon Society, New Orleans, Louisiana
Save Our Wetlands, Inc., Kenner, Louisiana
Sierra Club, Baton Rouge Chapter, Baton Rouge, Louisiana
The Fund for Animals, Inc., Jefferson, Louisiana
Trout Unlimited, San Antonio, Texas
Wildlife Management Institute, Southcentral Representative, Dripping Springs,
Texas
Wildlife Management Institute, Washington, District of Columbia

Others

Gulf of Mexico Fishing Management Council, Tampa, Florida
Gulf South Engineers, Inc., Houma, Louisiana
Houma Daily Courier, Houma, Louisiana
Morris Hebert, Inc., Houma, Louisiana
Carl Heck Engineers, Inc., Thibodaux, Louisiana
Louisiana Power & Light, Gretna, Louisiana
South Louisiana Electric Cooperative Association, Houma, Louisiana
Southern Consulting Engineers, Inc., Houma, Louisiana
T. Baker Smith & Son, Inc., Houma, Louisiana
Douglass Talbot Engineers, Inc., Houma, Louisiana
The Daily Comet, Thibodaux, Louisiana

8.1 Statement Commentators. Pertinent correspondence and responses to comments in the correspondence is presented in this section.

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Letter No. 1



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Washington, D.C. 20235
OFFICE OF THE ADMINISTRATOR

January 21, 1983

Colonel Robert C. Lee
District Engineer
New Orleans Corps of Engineers District
Department of the Army
P.O. Box 60267
New Orleans, LA 70160

Dear Colonel Lee:

This is in reference to your draft environmental impact statement entitled "Terrebonne Parish-Wide Forced Drainage System, Terrebonne Parish, Louisiana." Enclosed are comments from the National Oceanic and Atmospheric Administration.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving four copies of the final environmental impact statement.

Sincerely,

Joyce M. Wood
Joyce M. Wood
Chief
Ecology and Conservation Division

Enclosures: Letter from Richard J. Hoogland, National Marine Fisheries Service
Memo from Robert Rollins, National Ocean Service

Response 1.0: Comments taken into consideration; no COE response deemed necessary.



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tradition of service to the Nation

1 FEB 1983

Letter No. 2



**UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE**

Southeast Region
9450 Koger Boulevard
St. Petersburg, FL 33702

January 17, 1983

F/SERI/PK
(813)893-3503

Colonel Robert C. Lee
District Engineer, New Orleans District
Department of the Army, Corps of Engineers
P.O. Box 60267
New Orleans, LA 70160

Dear Colonel Lee:

The National Marine Fisheries Service (NMFS) has reviewed the Draft Environmental Impact Statement (DEIS) for Terrebonne Parish-Wide Forced Drainage System, Terrebonne Parish, Louisiana.

As the title indicates, the DEIS generally discusses the 26 proposed and 5 unauthorized projects for forced drainage in Terrebonne Parish. The eight major habitat types in the Parish are described in detail according to physical, biological, social and economic components, as well as the environmental consequences of probable direct and indirect beneficial and adverse impacts of the proposed projects and alternatives. We feel that the existing data on the Affected Environment (Section 4) and projected Environmental Consequences (Section 5) are summarized as adequately as possible for the entire project area (Terrebonne Parish) since the individual project plans are only proposed and are not the final project designs.

We support the wetland-nonwetland interface for the levee alignments as stated during previous meetings with the Corps of Engineers and Parish representatives. Levee alignment is generally indicated in the proposed plans shown in the habitat maps in Appendix A, as described in Section 3.2.3 and as verified in the Summary, page I-2. We recommend adherence to the wetland-nonwetland alignment during preparation of the specific applications for the 26 proposed projects. Those areas of wetlands within levees in the unauthorized projects should be maintained as wetlands with ingress and egress made available to marine organisms by either breaching the present levee, realigning the levee, installing weirs or other water control structures or any combination of the above.

The DEIS does not discuss the necessity for offsetting the loss of wetland habitats supportive of marine fishery resources or methods by which such offset mitigation could be accomplished. To determine the various habitat units that would be lost, modified or gained in the proposed forced drainage projects, we recommend that habitat evaluation procedures be conducted for the entire plan. A corresponding number of habitat units should be created, enhanced or maintained to avoid a net loss of habitat supportive of marine resources.

The last sentence in Section 2.6 states that "Permit issuance cannot be realized until U.S. Army Corps of Engineers' acceptance and approval of follow-up individual project environmental assessments." We assume that an individual public

Response 2.1: The text has been corrected on Page I-11 to read "Each project application, proposed or unauthorized, will include an environmental assessment detailing project specifics such as... mitigation based on Habitat Evaluation Procedures..."

Response 2.2: The text has been corrected in Section 2.6 on Page I-5 to read "All normal procedures associated with the public review relative to processing Section 10/404 Permit Applications will be in effect for each of the forced drainage projects including the right to elevation for review by higher authority."



1 FEB 1983

Letter No. 2(Cont.)

2

notice will be issued upon completion of an environmental assessment for each particular project as it is proposed for construction by the Parish. Therefore, we reserve our final comments, including the right to elevation for review by higher authority under Section 7b(1) of the Memorandum of Agreement between the Department of Commerce and the Department of the Army, until we have reviewed the detailed plans as advertised in the subsequent public notices and the accompanying environmental assessment.

2.2

Sincerely, yours,



Richard J. Hoogland, Chief
Environmental Assessment Branch

Letter No. 3



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
Rockville, Md 20852

January 21, 1987

TO: PP2 - Joyce H. Wood
FROM: N/MR - Robert R. Rollins *for*
SUBJECT: DEFS 8312.04 - Terrebonne Parish-wide Forced Drainage System
Pennsylvania Turnpike, Montgomery County, Pennsylvania

The subject statement has been reviewed within the areas of the National Ocean Survey's (NOS) responsibility and expertise, and in terms of the impact of the proposed action on NOS activities and projects.

Genetic control survey monuments may be located in the proposed project area. If there is any planned activity which will disturb or destroy these monuments, NOS requires not less than 90 days' notification in advance of such activity in order to plan for their relocation. NOS recommends that funding for this project includes the cost of any relocation required for NOS monuments. For further information about these monuments, please contact Mr. John Spencer, Director, National Genetic Information Center (NA/GIC) or Mr. Charles Mvuk, Chief, Network Maintenance Branch (NA/G172), at 600 Executive Boulevard, Rockville, MD 20852.

Response 3.1: Examination of records does not indicate the existence of genetic control monuments in any of project rights-of-way. Construction activities will be accomplished in full compliance with this request.



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Letter No. 4

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control
Atlanta GA 30333
(404) 452-4095
January 14, 1983

Dr. Thom Davidson
U.S. Army Engineer District
New Orleans Corps of Engineers
P.O. Box 60267
New Orleans, Louisiana 70160

Dear Dr. Davidson:

We have completed our review of the Draft Environmental Impact Statement (EIS) for Terrebonne Parish-wide Forced Drainage System, Terrebonne Parish, Louisiana. We are responding on behalf of the U.S. Public Health Service.

We note in the summary statement that "increased population coincident with new commercial and industrial development have resulted in invasion of low-lying areas prone to flooding." We encourage local officials to restrict where possible the encroachment upon floodplains and wetlands as intended by Executive Orders 11988 and 11990, Floodplain Management and Protection of Wetlands respectively. The Final EIS should indicate if the proposed project is compatible with the intent of these Executive Orders.

Under the no action alternative, it is stated that without the proposed forced drainage program the continued development and intense competition for available high land will result in increased pressure to utilize marginal wetlands for further development opportunities. Yet, under the preferred alternative, various wet acres within the proposed levees will convert to drier conditions which will enhance the utilization of these areas for industrial and other related uses. The draft statement also states that the "project construction will provide an incentive for development." Expected land use following project completion, specific zoning criteria for the project area, and potential future impacts resulting from project completion should be discussed in the Final EIS.

We noted on page V-20 that toxic materials, a variety of organic acids, heavy metals, and pesticides which exhibit persistent toxic effects, may be released into the water column during dredge and fill activities. The potential impacts of these occurrences should be clearly identified, and planned mitigation to prevent these impacts should be discussed in the Final EIS.

There was no mention in the Draft EIS regarding potential vector-borne disease impacts. The nature of the proposed action indicates that vector problems, specifically mosquitoes, are unlikely to occur as a result of the proposed work. However, the final statement should mention current mosquito problems in the area, expected impact the proposed plan will have on these problems, and planned mitigation measures should a problem occur.

Response 4.1: The text has been corrected in Section 4.1.3.3 on Page IV-94 to read "...Full compliance is indicated by using the wetland/nonwetland interface levee alignment. This assumes that nonwetlands are not in the floodplain..."

Response 4.2: The text has been corrected in Section 4.1.3.3 on Page IV-94 to read "...Full compliance is indicated...the only exceptions to this policy occur where: (1) minor wetlands are unavoidably encompassed...(2) the wetland/nonwetland interface is irregular...(3) extensive areas of wetlands encompassed...ate to be managed as wetlands."

Expected land use following project completion is discussed under the heading "Land Use" in Section V for each potential levee alignment in each habitat type.

To date specific zoning criteria has not been legislated for the Parish.

Potential future impacts resulting from project completion are discussed in Section V.

Response 4.3: The text in Section 5.4.1.1.6 on Page V-20 has been corrected to indicate that the extent of these toxic materials in sediments has not been determined at dredging sites.

Response 4.4: The text in Section 4.1.2.3 on Page IV-69 has been corrected to indicate that the proposed forced drainage projects are not expected to increase resident mosquito populations above existing levels. Terrebonne Parish has in existence numerous functional forced drainage projects none of which have demonstrated a need for mosquito control programs.

Page 2 - Dr. Thom Davidson

4.5
What is the present population the planned forced drainage project will protect? When the proposed project is completed, whose responsibility will ensure the upkeep and routine maintenance of the levees and pumps within the 26 proposed and 5 completed unauthorized components? If the pumps become inoperative due to electric failure or flood damage, what impact would such failure have upon the project area with regard to health, safety, and property? We note that the proposed levees will not provide protection against major flood conditions. What is the expected potential of major flood conditions? If this is determined significant, then we question the soundness of encouraging development in this area. The Final EIS should clarify this question.

Thank you for the opportunity to review this Draft EIS. We would appreciate receiving a copy of the final document when it becomes available. If you should have questions concerning our comments, please contact Mr. Ken Holt at (404) 262-6649, FTS 236-6649.

Sincerely yours,



Frank S. Lisella, Ph.D.
Chief, Environmental Affairs Group
Environmental Health Services Division
Center for Environmental Health

Response 4.5: Refer to populations Tables 1 and 2 in Appendix G.

Essentially only habitable areas in Terrebonne Parish are to be encompassed in proposed projects.

Responsibility for the maintenance and operation for the forced drainage system will be vested in the authorized governmental body.

Proposed electrical pumping facilities will be equipped with auxiliary diesel power.

Such natural devastations as hurricanes and associated major flooding are not infrequent occurrences. The indigenous population is experienced in coping with such disasters. With the assistance of an active and effective Civil Defense Program, health and property are protected to the maximum extent.

The stated purpose of the project is not to promote development but rather to provide reasonable protection from moderate flooding for existing developments. Historical evidence indicates the high probability of major flooding as a result of existing topological and meteorological convergence.

Letter No. 5



DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
FORT WORTH REGIONAL OFFICE
221 WEST LANCASTER AVENUE
P.O. BOX 2905
FORT WORTH, TEXAS 76113

RE: RM-VI

IN REPLY REFER TO

January 26, 1983

Colonel Robert C. Lee
District Engineer
New Orleans District
Corps of Engineers
Department of the Army
P.O. Box 60267
New Orleans, Louisiana 70160

Dear Colonel Lee:

This is to inform you that the Draft Environmental Impact Statement for the Terrebonne Parish-Wide Forced Drainage System has been reviewed in the U.S. Department of Housing and Urban Development's New Orleans Area Office and Fort Worth Regional Office and that it has been determined that the Department will not have comments on the subject Statement.

Sincerely,


Victor J. Hancock
Environmental Clearance Officer

Response 5.0: No CDF response deemed necessary



United States Department of the Interior
FISH AND WILDLIFE SERVICE

JACKSON MALL OFFICE CENTER
300 WOODROW WILSON AVENUE, SUITE 3185
JACKSON, MISSISSIPPI 39213

Letter No. 6

January 19, 1983

IN REPLY REFER TO:
Log no. 4-3-83-038

Mr. C. W. Decker
Chief, Regulatory Functions Branch
Department of the Army
New Orleans District, Corps of Engineers
ATTN: LM00D-SA
P.O. Box 60267
New Orleans, Louisiana 70160

Dear Mr. Decker:

This is in response to your letter of January 4, 1983, explaining the history and current status of the "Terrebonne Parish-Wide Forced Drainage System" Draft EIS.

Considering the situation as you described in your letter, we agree that in this case, the most reasonable approach would be to consider the impacts of each project individually, as the Environmental Assessment for that project is submitted. Each assessment must consider the cumulative impacts of the subject project, with reference to any previous construction that has occurred as a part of the overall plan.

We appreciate your concern for endangered species in this matter and look forward to coordinating with you on the individual projects within this plan, as they arise.

Sincerely yours,

Dennis B. Jordan
Dennis B. Jordan
Field Supervisor
Jackson Endangered Species Office

cc: D. FWS, Washington, D.C. (AFA/OES)
RD. FWS, Atlanta, GA (AFA/SE)
ES. FWS, Lafayette, LA
Department of Wildlife and Fisheries
New Orleans, LA

Response 6.0: Full compliance with the requirements of the endangered species act will be exercised as part of each individual project application.

Letter No. 7

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Project Review
Post Office Box 2088

ALBUQUERQUE, NEW MEXICO 87103



Dear Sirs:

Colonel Robert C. Lee
District Engineer
New Orleans District, Corps
of Engineers
Post Office Box 60267
New Orleans, Louisiana 70160
Dear Colonel Lee:

We have reviewed the draft environmental impact statement (EIS) for the Terrebonne Parish-wide Forced Drainage System, Terrebonne Parish, Louisiana, and have the following general and specific comments:

General Comments

The action being considered in this EIS is the issuance of a Section 404 permit for the construction and operation of a parish-wide forced drainage system. It is stated that this phase of the EIS is a general statement for 5 previously constructed but unauthorized projects and 26 new proposed projects. It is further stated that permit issuance will be determined on the acceptance of this general phase and approval of follow-up individual project environmental assessments.

We note that the 5 unauthorized projects have enclosed 7,262 acres of wetlands while the 26 proposed projects would enclose an additional 6,438 acres of wetlands.

We concur with the approach of an area wide EIS which will provide a level of analysis necessary to determine the degree of impacts that can be expected to occur with a large number of projects such as the 31 included in this EIS. We concur with the preferred alternative discussed in this statement for placing levee alignments which is identified as the wetland/non-wetland inter-face alternative. This alternative should provide the necessary guidance for the further planning of individual projects and result in the use of minimal areas of wetlands for the 26 proposed projects and their cumulative impact.

It will be helpful to have this analysis for use in tiering the future site specific environmental analysis when more detailed project information is provided for use in the analysis and subsequent permitting decisions related to the 31 projects.

It is stated in the EIS that the 5 unauthorized projects result in "... no direct adverse impacts to wetlands." However, we find that these existing

Response 7.1.1

The 26 proposed and 5 unauthorized projects in the forced drainage system will be considered for individual 404 permits each of which is subject to normal processing procedures including permission, denial, or referral to higher authorities for decision.

unauthorized projects have allowed conversion of thousands of acres of valuable wetlands to pasture and scrub-shrub habitats and eliminated their functional value as nursery habitat for marine organisms. Our Fish and Wildlife Service (FWS) has previously recommended that action be taken to restore the illegally enclosed wetlands impacted by these 5 projects. Such recommendations were contained in letters dated November 25, 1975, and December 8, 1977, to your office. The EIS should discuss the disposition of these recommendations.

7.2

It is not clear how the preferred alternative of the wetland/non-wetland interface will be applied in making the permit decisions concerning the 5 unauthorized projects. This should be explained in detail.

On January 11, 1983, a meeting was held with representatives of the applicant, other Federal and State agencies and your office. The Corps representative indicated that the applicant has been advised by letter, that the issues concerning the 5 unauthorized projects would have to be resolved before acceptance by the Corps of any new applications for additional forced drainage projects. The Corps representative added that the applicant may be required to either breach, degrade, re-align or place weirs in the unauthorized project levees. The applicant may also be required to comply with other stipulations that have not yet been developed with regard to the unauthorized projects. We note that none of these actions have taken place nor is there any discussion of these actions as part of this EIS.

7.3

We concur with the approach specified in the EIS that the specific details of each project will be processed and reviewed as individual permit actions. The issues concerning these 5 projects will need to be resolved and their impacts identified prior to consideration of the permit applications for the additional 26 drainage projects. The preferred alternative for placing levee alignments along the wetland/non-wetland interface will not be applicable in most instances with the 5 unauthorized projects since their levees were constructed prior to utilization of this criteria for minimizing impacts to wetlands.

This statement should clearly discuss how this cumulative relationship between the 5 unauthorized projects will be handled before permitting decisions are made for the proposed additional 26 projects.

7.4

As briefly discussed in this EIS the mode of water level management to be followed for the 5 unauthorized projects will cumulatively relate to the impacts that will have to be considered in the further permitting of the additional 26 proposed projects. This relationship should be discussed in the EIS.

Specific Comments

Summary

Page I-1, paragraph 5 - The meaning of the last sentence is unclear; this statement should be clarified as to how and to what extent the enclosed wetlands will be maintained as such. If the enclosed wetlands have a history of tidal ingress and egress, a statement regarding the maintenance of this

7.5

Response 7.2: The text has been corrected in Section 2.6 on Page II-5 to indicate that previous comments received concerning the unauthorized projects will be taken into consideration and additional comments will be requested as a part of the normal 404 application project review.

Response 7.3: Decisions concerning individual projects will be made based on data included in the individual assessments and comments received relative to the alternatives in the normal processing procedures.

Response 7.4: Due to the general nature of this generic EIS it is not deemed appropriate to detail specific individual project impacts, those data are to be expanded in the individual assessments that will be tiered onto this document.

Response 7.5: The text has been corrected in Section 4.1.3.3 on Page IV-94 to read "Full compliance is indicated by utilizing the wetland/nonwetland interface levee alignment. This assumes that nonwetlands are not in the floodplain. The only exceptions to this policy occur where: (1) minor wetlands are unavoidably encompassed where immediately adjacent to existing developments; (2) the wetland/nonwetland interface is so irregular as to economically prohibit strict adherence; and (3) extensive areas of wetlands encompassed within project boundaries ... are to be managed as wetlands.

The ultimate fate of the 5 unauthorized projects will be determined on an individual basis with the normal public review associated with permit processing."

evaluation should be included in this section and discussed in more detail in further sections of the statement.

Page I-II, paragraphs 2 and 4 - We do not see how in actual practice placement of project levees along wetland/non-wetland interface as now proposed will minimize impact wetlands. A review of habitat maps for the project area reveals that both the unauthorized and proposed project levees in many instances do not follow the wetland/non-wetland interface. Additional discussion should be provided in the document as to how the existing projects will be mitigated and the proposed projects retained to minimize impact wetlands. The inclusion of 13,700 acres of wetlands in the forced drainage system is not a minimal impact. This should be recognized in the statement and impacts to this land discussed.

7.6

Page I-II, paragraph 1 - The statement that drier conditions resulting from forced drainage may result in utilizing marsh areas for cattle grazing or other man-related uses conflicts with the statement found on page I-I that wetlands included in drainage projects would be maintained as wetlands. This discrepancy should be clarified in the statement by indicating the type of water-level management presently being followed, as well as proposed future water-level management, in the project area. Mitigation of unavoidable impacts resulting from the forced drainage system should be summarized in this section and discussed in detail in the Environmental Consequences section.

7.7

Page I-II, paragraph 3 - We do not agree with the statement that it is nearly impossible to predict project impacts without extensive research. The nature and extent of habitat changes associated with dredging, filling, and possible wetland drainage can be translated into changes in species composition, carrying capacity, and other indications of project impacts on living natural resources. This statement should be deleted.

Page I-II, paragraph 4 - We are not in agreement with the conclusion that the unauthorized projects have not had adverse impacts on and have maintained the integrity of the enclosed wetlands. Site observations by FWS personnel indicate that the conversion of extensive coastal marshes to drier, less productive scrub-shrub and pasture habitats as a result of forced drainage and subsequently reduced water levels has occurred. These unauthorized levees have also eliminated ingress and egress of marine organisms and precluded their use of valuable nursery areas.

7.9

Introduction to the Project

Page II-4, paragraph 2.4.2 - It is stated that one of the objectives of this project is that wetlands encompassed within forced drainage areas will be maintained as wetlands and protected from deleterious saltwater intrusion. However, this statement conflicts with paragraph 1 on page I-II which indicates that drier conditions resulting from forced drainage would result in cattle grazing and other man-related uses. This discrepancy should be clarified in the statement.

7.10

Page II-4, paragraph 2.6 - It should be clearly stated that each of the 5 unauthorized and 26 proposed projects will be considered in separate

Response 7.6:

The proposed levee alignments which utilize to the maximum extent practicable the wetland/nonwetland interface were defined in meetings in which a representative of the US Fish and Wildlife Service Lafayette Area Office, was an active participant. Additionally, levee alignments will not be finalized until alternatives are addressed in the individual assessments and comments are taken into consideration in the normal review process.

The text has been corrected in Section 2.6 on Page II-5 to indicate that mitigation is a potential consideration in the permitting process.

Response 7.7:

The text has been corrected in Section 4.1.3.3. on Page IV-94 to differentiate between minor wetland areas that may be pumped and utilized and major wetland areas that are to be maintained.

Response 7.8:

Correction made.

Response 7.9:

The text has been corrected on Page I-11 to read "Impacts to project areas resulting from construction of the 5 unauthorized drainage projects are evident. To what degree these impacts are beneficial, detrimental and/or irreversible has not been determined. It appears that these projects have maintained the integrity of enclosed wetlands by preventing salt water intrusion and subsequent deterioration or conversion of these wetlands to open water areas as has occurred in adjacent unprotected habitat."

Response 7.10: See Response 7.5.

submitted section 10-404 permit applications. In addition, it should be noted in this section whether concerned Federal and State agencies will review and comment individual environmental assessments for each of the projects prior to issuance of formal public notices. A statement regarding the applicability of the 1982 Memorandum of Agreement between the Departments of Army and Interior as related to elevation of the individual permit applications should be included in this section.

7.11

Alternatives

Page 11-2, paragraph 1 - Reference previous comments regarding Page 1-2, paragraphs 2 and 4.

7.12

Affected Environment

Page 11-11, paragraph 1 - It is noted in the EIS that the decline of the local water table is a major controlling factor in accelerated subsidence. We recommend that consideration be given to measures to monitor surface-water discharge and water table decline within those forced drainage projects that span and impound inter-levee wetland basins.

7.13

Page 11-69, paragraph 4.1.2.2 - In a December 7, 1982, letter to your office the EIS requested that a biological assessment be prepared that specifically addresses the effects of the project on endangered, threatened or proposed species occurring in the project vicinity. The letter also lists seven items that should be included in this biological assessment. We recommend that this assessment be appended to and included as part of the final statement.

7.14

Pages 11-91 through 11-94, paragraph 4.1.3.3 - This section does not document compliance with Executive Order 11988. The Water Resources Council published "Guidelines for Implementing Executive Order 11988 - Floodplain Management" in the Federal Register, Vol. 43, No. 29, on February 10, 1978. The objective of that order is to "... avoid to the extent possible the long- and short-term adverse impacts associated with occupancy and modifications of floodplains and to avoid direct or indirect support of floodplain development whenever there is a practicable alternative" The basic purpose of the proposed project included in this EIS is to provide drainage to areas presently susceptible to flooding. A direct result of this action will be the encouragement of development in areas that are currently not suitable for development due to flooding hazards. The EIS does not, provide an adequate description of the management of the floodplain (especially wetlands) within the existing and proposed drainage projects. The above-referenced guidelines encourage the restoration of floodplains which have been impacted as a result of prior action; this is especially pertinent to the 7,262 acres of wetlands that have been enclosed and partially drained by the 5 unauthorized projects included in the EIS. The above referenced guidelines also state that the action agency "... must design or modify the action to assure that it will be carried out in a manner which preserves as much of the natural and beneficial floodplain values as is possible." This EIS does not contain sufficient information for the reviewers to ascertain whether or not the proposed action will preserve the natural values of the floodplain in those areas impacted by the proposed project. Because of these shortcomings in this section of the EIS we find that the proposed

7.15

Response 7.11: The text has been corrected in Section 2.6 on Page 11-5 to read "This EIS should be considered a general statement for all 26 proposed and 5 unauthorized projects. Permit issuance cannot be realized until US Corps of Engineers acceptance of the EIS and acceptance and approval of follow-up individual project environmental assessments. All normal procedures associated with public review relative to processing Section 10/404 Permit Applications will be in effect for each of the 31 forced drainage projects including possible mitigation measures and the right to elevation for review by higher authority."

Response 7.12: See Response 7.6.

Response 7.13: This recommendation is taken under advisement.

Response 7.14: See Response 6.0.

Response 7.15: See Response 7.5.

action is not in full compliance with Executive Order 11988, as indicated in Page IV-6.

Page IV-9, Paragraph 4.1.4.5.3 - As fishery resources are related to the available area of wetlands, a large reduction in this acreage by the existing unauthorized and proposed forced drainage projects may significantly affect commercial fisheries. At the very least, such a reduction in wetlands would contribute to the cumulative adverse impacts on commercial fisheries associated with ongoing habitat loss in coastal Louisiana. This should be recognized in the statement.

Page IV-97, Paragraph 4.1.4.5.4 - The importance of mineral resources to Terrebonne Parish is mentioned in this section. However, the expected impacts, if any, on mineral resources and production facilities are not mentioned. This section should be revised to describe expected impacts of the project on mineral resources in the area and discuss plans for minimizing such impacts.

Page IV-137, Paragraph 4.6.2.4 - Reference comments listed for page IV-69, Paragraph 4.1.2.2.

Environmental Consequences

This section should be revised to include a discussion of the impacts of prior, existing and anticipated future water-level reduction on the wetlands enclosed by the 5 unauthorized forced drainage projects, as well as the impacts on wetlands to be encompassed and possibly de-watered by the 26 proposed projects.

This section should also include a summary table listing the individual drainage projects and provide information regarding the total acreage of each habitat type included in the project. This table should include the total acreage of each habitat type to be impacted by each alternative grouping of projects, i.e., wetland non-wetland, and wetland/non-wetland interface alternatives. A separate estimate of the acreage of each wetland type affected by the existing unauthorized projects should also be included.

Summary

In conclusion we believe the wetland resources that have been or could be impacted by the 31 projects are of major significance. The final statement should address the above detailed comments and concerns and also clearly indicate that future permit actions will be based on the condition of avoidance of significant wetland areas and mitigation of impacts where avoidance is not possible. Because of our concerns, we may depending on the proposals included in the final statement, refer this project to the Council of Environmental Quality under Section 1504 of the Council's regulations for implementing the procedural provisions of the National Environmental Policy Act. However, we would be willing to coordinate our efforts fully at the earliest possible time to resolve our concerns with a minimum of delay which would eliminate the necessity for any future referral. Coordination can be initiated by contacting the Field Supervisor, Division of Ecological Services, U.S. Fish and Wildlife Service, P. O. Box 4305, Lafayette, Louisiana 70002 (118-214-7478).

Response 7.16: The text has been corrected in Section 5.2.1.4 on Page V-7 to read "The probable change in habitats will result in a change of the types and quantities of species harvested."

Response 7.17: Refer to Paragraph 5.4.1.4 on Page V-24.

Response 7.18: See Response 6.0.

Response 7.19: See Response 7.4.

Response 7.20: See Tables III-1 and III-2 on Pages III-3 and III-4.

7.16

7.17

7.18

7.19

7.20

Letter No. 7 (Cont.)

in reviewing the future permit applications and accompanying environmental assessments for the individual drainage projects, the personnel will be able to work closely with representatives of the applicant and its consultants, your office and with other agencies to develop project plans and water-level management schemes that minimize losses of valuable wetlands and mitigate for unavoidable loss of these wetlands. We are hopeful that such plans can be developed so that the wetlands enclosed by the existing unauthorised works are restored or preserved, as appropriate; and that the proposed new projects will minimize adverse impacts on productive wetland habitats.

Sincerely,

Raymond P. Churan

Raymond P. Churan
Regional Environmental Officer

Letter No. 8



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VI
1201 ELM STREET
DALLAS, TEXAS 75270

February 15, 1983

Colonel Robert C. Lee
District Engineer
New Orleans District
U.S. Army Corps of Engineers
P.O. Box 60267
New Orleans, Louisiana 70160

Dear Colonel Lee:

We have completed our review of the Draft Environmental Impact Statement (EIS) entitled "Terrebonne Parish-Wide Forced Drainage System, Terrebonne Parish, Louisiana".

For your convenience, the following comments are offered for consideration:

1. Preparation of this Draft EIS is stated as being at the request of the New Orleans District Corps of Engineers to accompany subsequent 404 permit applications for twenty-six individual projects of the Terrebonne Parish drainage system. We understand that overall impact evaluation is being considered on a generic basis at this planning stage. Subsequent permit issuance and approval will require and would not be realized until all follow-up site specific environmental assessments have been completed and submitted for public and agency review and comment.

In view of these facts, we ask the New Orleans District to refer to 40 CFR 1502.20 of the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (NEPA), Section 1502.20 encourages agencies to tier their environmental statements to eliminate repetitiveness and to focus on the issues ready for decision. Since fully completed site specific assessments will be required for each individual project with detailed Section 404 (b)(1) evaluations pursuant to 40 CFR Part 230, we encourage the New Orleans District to tier subsequent assessments to the Draft EIS. The 40 CFR 1502.20 states whenever broad or generic EIS's are prepared, all subsequent statements or assessments need only to summarize the issues discussed in the broader EIS. Following assessments should concentrate on impacts specific to the subsequent action. Additionally, all following assessments should specify where the generic document can be made available.

2. The generic Draft EIS has been prepared to document and evaluate Stage I environmental consequences of possible authorized and unauthorized (after-the-fact) drainage project objectives. Review of the authorized actions indicates minimal water and wetland habitat impacts should occur. These plans provide flood protection in the upland, non-wetland areas.

Response 8.0: Comments taken into consideration; no COF response deemed necessary.

The unauthorized actions, which have been in place for over ten years, encompass wetland resources. These include projects 3-2, 4-1, 9-1, 8-2C, and 8-2D. The EIS states there is no evidence of significant adverse impact to the project areas of the unauthorized actions. It is stated these actions are currently contributing to maintain the integrity of enclosed wetlands by preventing saltwater intrusion and subsequent deterioration and conversion of these wetlands to open water areas as a result of subsidence.

In an effort to preserve wetland integrity in the unauthorized project areas, we suggest Stage II planning and subsequent assessments provide project modification features such as weirs, flap gates, and/or land use planning constraints to further ensure wetland characteristics are maintained. Your recommendations should be made conditions to the subsequent 404 permit applications for the after-the-fact projects. Discussion of these matters should be included in the Final EIS.

We classify your Draft Environmental Impact Statement as LO-2. Specifically, we have no objections to Stage I planning and the stated project objectives. Wetland impacts for the authorized projects appear to have been minimized. Stage II planning should carefully evaluate measures to include structural features or land use planning constraints within the existing unauthorized projects to ensure wetland ecosystems retain their identified integrity. Finally, we ask that subsequent assessments for each individual permit applied for be tiered to the Draft Statement pursuant to 40 CFR 1502.20. Our classification will be published in the Federal Register in accordance with our responsibility to inform the public of our views on the Proposed Federal Action under Section 309 of the Clean Air Act.

Definitions of the categories are provided on the enclosure. Our procedure is to categorize the EIS on both the environmental consequences of the proposed action and on the adequacy of the EIS at the draft stage, whenever possible.

We appreciate the opportunity to review the Draft EIS. Please send our office five (5) copies of the Final EIS at the same time it is sent to our Office of Federal Activities, U.S. Environmental Protection Agency, Washington, D.C.

Sincerely yours,


Dick Whittington, P.E.
Regional Administrator

Enclosure

LO - Lack of Objections

EPA has no objections to the proposed action as described in the draft impact statement; or suggests only minor changes in the proposed action.

ER - Environmental Reservations

EPA has reservations concerning the environmental effects of certain aspects of the proposed action. EPA believes that further study of suggested alternatives or modifications is required and has asked the originating Federal agency to re-assess these aspects.

EU - Environmentally Unsatisfactory

EPA believes that the proposed action is unsatisfactory because of its potentially harmful effect on the environment. Furthermore, the Agency believes that the potential safeguards which might be utilized may not adequately protect the environment from hazards arising from this action. The Agency recommends that alternatives to the action be analyzed further (including the possibility of no action at all).

ADEQUACY OF THE IMPACT STATEMENT

Category 1 - Adequate

The draft impact statement adequately sets forth the environmental impact of the proposed project or action as well as alternatives reasonably available to the project or action.

Category 2 - Insufficient Information

EPA believes the draft impact statement does not contain sufficient information to assess fully the environmental impact of the proposed project or action. However, from the information submitted, the Agency is able to make a preliminary determination of the impact on the environment. EPA has requested that the originator provide the information that was not included in the draft statement.

Category 3 - Inadequate

EPA believes that the draft impact statement does not adequately assess the environmental impact of the proposed project or action, or that the statement inadequately analyzes reasonably available alternatives. The Agency has requested more information and analysis concerning the potential environmental hazards and has asked that substantial revision be made to the impact statement. If a draft statement is assigned a Category 3, no rating will be made of the project or action, since a basis does not generally exist on which to make a determination.



DAVID C. THRENT
Governor

STATE OF LOUISIANA
DEPARTMENT OF CULTURE, RECREATION AND TOURISM
OFFICE OF PROGRAM DEVELOPMENT

Letter No. 9

ROBERT B. DEBLIEUX
Assistant Secretary

MRS. LAWRENCE H. LEE
Secretary

February 10, 1983

Colonel Robert C. Lee
District Engineer
Department of the Army
New Orleans District, Corps
of Engineers
Attention: LMH00-SA
P. O. Box 60267
New Orleans, LA 70160

Re: Draft Environmental Impact Statement
Terrebonne Parish-wide Forced
Drainage System
Terrebonne Parish, Louisiana

Dear Colonel Lee:

My staff has reviewed the above-referenced document and the following comments are offered for your consideration.

It is our opinion that the D.E.I.S. presents a thorough overview of known cultural resources in the various project areas and meets the criteria for a Phase I study. We also agree with the recommendation on page IV-87 for on-site surveys of the proposed construction zones during Phase II.

The only corrections we have concerning the cultural resources section in the D.E.I.S. are the following. In subsection 4.1.3.2.1 on page IV-71, "permit request reports" should read "Cultural resources survey reports." In subsection 4.1.3.2.2, 16T-5 should be 16TR5. In subsection 4.1.3.2.10, please note that Ardayne Plantation was listed in the National Register of Historic Places on November 1, 1982. Finally, we would prefer that the archaeological site distribution map on page IV-81 not be included in the F.E.I.S. to protect the sites from possible vandalism.

If we may be of further assistance, do not hesitate to contact my staff in the Division of Archaeology.

Sincerely,

Robert B. DeBlieux
State Historic Preservation Officer

Response 9.1: Corrections have been made as indicated.

Letter No. 10

State of Louisiana



FRANK J. CHAMBERS
DEPUTY SECRETARY

DEPARTMENT OF NATURAL RESOURCES

WINSTON R. DAY
DEPUTY SECRETARY

January 27, 1983

Dr. Thom Davidson
Corps of Engineers
Regulatory Functions Branch
New Orleans District
P. O. Box 60267
New Orleans, LA 70160

RE: Terrebonne Parish-Wide Forced Drainage System
Draft EIS

Dear Dr. Davidson:

The CHS has reviewed the draft EIS for the Terrebonne Parish Wide drainage system. Please be advised that our office has no substantial objections to the EIS as a generic document providing background information relevant to the overall impacts which might occur as a result of the implementation of the proposed projects. Attached is a list of minor errors which have been detected and some suggestions for inclusion in the FEIS.

Our main concern is that assurance be given that the Coastal Management Section shall have the opportunity to review all environmental assessments prepared for individual projects in conjunction with the applications for Section 404 (CWA) and Coastal Use Permits as required by 15 CFR 930.58. We suggest that it be spelled out that these documents will be provided to each agency responsible for issuing permits for the projects or which may have substantial responsibilities within project areas.

Secondly, CHS believes that the EIS and future assessments for the projects not yet undertaken are subject to federal consistency regulations, and that consistency certification should be a part of each document under Section 307(c)(3A) of the CZMA (1972).

The Coastal Management Section also has an obligation under 15 CFR 930.64 to participate in negotiation of possible mitigation for significant adverse impacts occurring as a result of any of the 26 proposed or 5 unauthorized

Response 10.1: See Response 7.11.

Response 10.2: Full compliance with the requirements of Section 307(c)(3A) of the CZMA (1972) will be exercised as a part of each individual applications.

Response 10.3: The text has been corrected on Page I-11 to read "Each project application proposed or unauthorized will include an environmental assessment detailing project specifics such as...mitigation based on Habitat Evaluation Procedures..."

Letter No. 10(Cont.)

Projects which lie in the Coastal Zone or may affect the Coastal Zone. The Coastal Management Section may also wish to participate and/or comment on any Habitat Evaluation Procedure (HEP) used for any of the subject projects.

Sincerely,

JOEL L. LINDSEY
CHS/DNR Administrator

JLL:TH/cb

Enclosure

cc: Mr. George Hecht, Terrebonne Parish Police Jury
Mr. Horace Thibodaux, T. Baker Smith & Son
U.S. Fish and Wildlife Service
National Marine Fisheries Service
Environmental Protection Agency
Jesse Gundry, LA Dept. of Wildlife & Fisheries

Letter No. 10(Cont.)

TERRIBONNE PARISH DRAFT EIS - FORCED DRAINAGE
COMMENTS ON TEXT

Response 10.4: No plans exist at present for wetland alignments.
Response 10.5: Corrections made as indicated.

- | | | |
|------|--------------------------|---|
| 10.4 | Page III-1, Table III-1: | Arreage does not reflect existing project plans for wetland alignment. We suggest modification. |
| | Page IV-28, ¶7, Line 1: | Word left out of sentence. |
| 10.5 | Page IV-29, ¶3, Line 7: | Word habitats misspelled. |
| | Page IV-62, ¶7, Line 8: | pH misspelled. |



David C. Ferrin
Governor



David C. Ferrin
Governor

Letter No. 11

Department of Transportation and Development

P. O. BOX 44245 CAPITOL STATION
BATON ROUGE LA 70804

(504) 342-7520

January 4, 1983

Colonel Robert C. Lee
District Engineer
U.S. Army Engineer District
P. O. Box 60257
New Orleans, Louisiana 70160

RE: LMNOD-SA
DEIS Terrebonne Parishwide
Forced Drainage System
Terrebonne Parish, Louisiana

Dear Colonel Lee:

In response to your letter of November 24, 1982, the only comment the Louisiana Department of Transportation and Development has to offer relates to permits. A permit will be required from the Department for any work performed within the right-of-way limits of a state Highway.

Should you have any questions regarding this matter, please contact Mr. P. J. Frederick, Chief Maintenance and Operations Engineer.

Sincerely,

V. Pizzicato

VINCENT PIZZICATO
PUBLIC HEARINGS AND
ENVIRONMENTAL IMPACT ENGINEER

VP/DJM/na

- cc: Mr. Neil L. Wagoner
- Mr. Dempsey D. White
- Mr. Jack R. Reid
- Mr. Frank M. Herroy, Jr.
- Mr. P. J. Frederick
- Mr. Clyde Soreau
- Mr. James Forbes
- FJMA

Response 11.1: Full compliance with the Louisiana Department of Transportation and Development will be exercised as part of each individual project application.



DEPARTMENT OF WILDLIFE AND FISHERIES
401 PULASKI STREET
NEW ORLEANS 70130

DAVID GREEN

(504) 342-9274
January 14, 1983

Mr. Charles Decker
New Orleans District, Corps of Engineers
P. O. Box 60267
New Orleans, Louisiana 70160

RE: Draft Environmental Impact Statement
Terrebonne Parish-Wide
Forced Drainage System

Dear Mr. Decker:

Personnel of the Louisiana Department of Wildlife and Fisheries have reviewed the above referenced statement and offer the following comments.

The information and data provided within the environmental impact statement covers the entire parish in general along with the possible impacts of the forced drainage system. We request the opportunity to review and comment on each of the assessments developed for the 26 proposed and five unauthorized projects and their alternatives.

Mitigation of significant adverse impacts will be required for these projects. In order to adequately evaluate the impacts, we request that habitat Evaluation Procedure (HEP) be used with each project.

As stated in the report, the wetland/non-wetland alignment of the levees was chosen on the basis of minimal impacts on wetland and maximum use of upland space. The maps indicating this only represented the approximate location of levees. The actual or exact locations of the levees will be determined at the time of each project permit application.

We appreciate the opportunity to review this project during early planning stages.

Sincerely,

Jesse J. Guidry
Jesse J. Guidry
Secretary

JJG/FDD/fs
FWS
MMES

EPA
Mr. Ralph Latapie
Mr. Mike Windham
DNR - CFS

An Equal Opportunity Employer

Response 12.1: See Response 7.11.

Response 12.2: The text has been corrected on Page 1-11 to read "Each project application proposed or unauthorized will include an environmental assessment detailing project specifics such as...mitigation based on Habitat Evaluation Procedures..."

Response 12.3: Comment noted.

Letter No. 13(Cont.)

remains a mystery, since the projects illustrated have no apparent direct bearing on these problems.

P. 1-4. Since only three acres of saline marsh lie within the proposed project areas, and since completion of the projects as proposed will have only a minimal detrimental impact on saline marshes, we will dispense with any further discussion thereof on the grounds that we have no substantial objections to the projects as they relate to saline marshes.

P. 1-4 & 5. Quoting from the EIS:
"There are 875 acres of brackish marsh within the project areas. Brackish marshes are generally associated with high land loss rates."

The brackish marsh has the greatest live biomass of any marsh type. Muskrats are most abundant in brackish marshes. The marshes also serve as important nursery grounds for sport and commercial species. The dominant emergent macrophytes for brackish water bays comes from the emergent macrophytes to the upper trophic levels via detritus washed into the estuaries."

According to your levee alignment criteria, no acres of brackish marsh should be included within the project areas. From your own environmental evidence, all such marshes should be deleted from inclusion within the proposed projects.

P. 1-5. Primary productivity of intermediate marshes is even higher than that of brackish marshes (2,800 g/m²/yr. v. 2,756 g/m²/yr.). Areas of intermediate marsh are located within the proposed and unauthorized project areas. The intermediate marsh habitat supports a transitional community of organisms which includes both marine and freshwater forms. Intermediate marshes are preferred feeding grounds for herbivorous waterfowl including the dabbling ducks which are prized by hunters. Alligators prefer this marsh type, which produces an alligator. Alligators with almost twice the density of other marsh types. According to your levee alignment criteria, no acres of intermediate marsh should be included within the project areas. From your own environmental evidence, all such marshes should be deleted from inclusion within the proposed projects.

F. 1-1. Terrebonne Parish has lost approximately 40% of its freshwater marshes in the last 25 years alone - an astounding total of over 125,000 acres. This alone is more than reason enough to insure that no more such marshes will be lost. Quoting:
"There are 2,976 acres of freshwater marsh distributed within the project areas."

Fresh marsh contains the highest diversity of plant species. Water bodies within a freshwater system act as conduits transporting materials to more downstream areas. Deposition of these materials represents an important source of raw materials to the lower estuary. According to your levee alignment criteria, no acres of freshwater marsh should be included within the project areas. From your own environmental evidence, all such marshes should be deleted from inclusion within the proposed projects.

F. 1-2. P. 1-13-137. Over 2,000 acres of cypress-tupelorum swamp lie within the project areas. These swamps are important habitat for mammalian and avian species, and are favored by the red swamp crawfish. Quoting:
"There are four confirmed active bald eagle nests in the Terrebonne Parish area. Nesting occurs in either large cypress or oak trees. One site, near Greenwood, is within one mile of a proposed construction zone. Swamps and bottomland hardwood forests are prime habitat for the now rare black bear. One night-hawk was reported in a swamp-bottomland hardwood forest area near the project. The project, under areas of special concern, you assert that in some cases, swamp areas within proposed project boundaries will be protected against erosion, but you do not explain how

13.6

13.7

13.8

13.9

Response 13.6: Comments concerning levee alignments inclusions and exclusions will be invited during the review period as part of individual project applications.

Response 13.7: See Response 13.6.

Response 13.8: See Response 13.6.

Response 13.9: See Response 6.0.

Letter No. 13(Cont.)

these swamps will be maintained as healthy environments (flood-
-ates, verra, etc.) or how they might still be utilized by
species such as bears (forested corridors, etc.). when surrounded
by developed areas. Also, on p. V-37: "Cypress-tupelo swamp areas
within project boundaries will probably gradually convert to
drier bottomland hardwoods." Why?
According to your levee alignment criteria, no acres of cypress-
tupelo swamp should be included within the project areas.
From your own environmental evidence, all such swamps should be
excluded from inclusion within the proposed projects.

13.10

According to your own statements (p.V-30), bottomland hard-
-woods as a whole are an area of special concern:
"The continued loss of these wetlands, their associated values,
and their contribution to Terrebonne Parish habitat diversity
should be given special concern."
p. 1-7 "These areas serve as important wildlife refuge areas
within high water level conditions."
"Wood ducks nest in...seasonally flooded bottomland hardwood
-forests."

"The white-tailed deer and black bear are two big game mammals
which inhabit bottomland hardwoods."
"The species of fish utilize bottomland hardwoods during inunda-
-tions."
p. 1-13: "Portions of Harmande Ridge, Bayou Mauvais Bois and
other small isolated areas still contain some mixed hardwood
habitat that is not bordered by a non-related habitat...In at
least one case, the endangered American bald eagle utilizes this
habitat as a nesting site..."

13.11

Respectfully all of the above, we read that there are 5,847 acres of
this habitat type within 22 project areas. We are not informed
as to the total number of acres of bottomland hardwoods which
should not only lie outside the proposed project areas, but which
should be insulated permanently from development. This is crucial
information, and should be included, as well as information on
the most vital areas to wildlife, and whether they will be pro-
-tected from development.
According to your levee alignment criteria, no acres of bottom-
land hardwood forest should be included within the project areas.
From your own environmental evidence, all such wetlands should be
excluded from inclusion within the proposed projects.

No find more contradictory statements on pp. 1-10 and 1-11.
While it may save a lot of money by not developing wetlands
which occur within the proposed project areas, it will do ir-
-reparable damage to those wetlands unless they are managed in
such a way as to be subject to tidal flow. Dredging:

"There is no evidence of any significant adverse impacts to
project areas resulting from construction of the 3 unauthorized
drainage projects". This statement may be true today, but quite
obviously, it will not hold true in the future. Impounded wetlands
must be water managed, otherwise siltation and stagnation will occur.
Nutrient flow will be blocked. Siltation and stagnation will occur.
Contributions to and from adjacent wetlands will be terminated.
This is highly undesirable, and is unnecessary both economically
and environmentally.

You yourselves offer other evidence against the inclusion
of any wetlands within the project areas:
p. 1-13 "...csh marsh soil...contain the highest organic content..."
p. 1-17: "The entire freshwater marsh area could be regarded as
an area of special concern..."

p. 1-10 "As early as 1932, Bendie, studying water quality in
African lakes, noted that water quality was much better in a lake
where the inflow passed through a wetland than in an adjacent
lake without wetlands. In recent years, many authors have sup-
-ported that wetlands are excellent nutrient traps and are a
result valuable because they are acting as natural treatment
plants, removing V and P from polluted water passing through them..."

13.13

Response 13.10: See Response 13.6.

Response 13.11: See Response 13.6.

Response 13.12: See Response 7.5.

Response 13.13: See Response 7.5.

Letter No. 13(Cont.)
 p. IV-22: "...early all of the levee hardwood forests originally
 covering Terrebonne Parish have been cleared..."

P. IV-25: The soil associations table gives no data for
 projects 8-1, 8-2D, 8-2, and 8-2C. Why not? The habitat
 maps are extremely difficult to decipher, both in terms of
 habitat within project areas, and sometimes as to which project
 basins and ends where? May we suggest that in the Final EIS
 separate colors be used (i.e., red, green, etc.) instead of
 shades of a single color, and that each project limit be clearly
 defined.

We have serious reservations about the merits of many of
 the proposed projects. These reservations may be divided into
 two categories: a) projects requiring total deletion, and b)
 projects which may be acceptable if corrective management
 proposals are made and accepted as workable by the U. S. Fish &
 Wildlife Service, the National Marine Fisheries Service, and the
 U.S. Dept. of Natural Resources, or altered.

a) Projects 8-1, 8-2C, 8-2D, 8-2E, the sale of land reclamation,
 These projects exist primarily for incidental or commercial develop-
 ment and are not needed for either habitat or commercial develop-
 ment. We strongly urge that these projects be removed from con-
 sideration, and that the easement involved be restored to their
 natural condition and waterflow regime.
 b) Projects 8-1 and 8-2B are also prime candidates for deletion
 unless a very good and workable management plan can be drawn up.
 We also request individual management plans for projects 1-1A,
 1-1B, 1-1B, 1-1A, 8-6, 8-6, 8-2A.

We thank you for this opportunity to comment. May we suggest
 that what Terrebonne Parish needs is sewage treatment, a fresh-
 water diversion plan, and levees to serve developed areas, rather
 than land reclamation projects.

Yours truly,

Richard J. Woodland
 Richard J. Woodland, Member
 Orleans Audubon Society
 Conservation Committee

- cc
- 1) Donald P. Landry, Juror
 Terrebonne Parish Police Jury
 District 1, Precinct C
 P. O. Box 2768
 Thibodaux, La. 70311
 - 2) Richard J. Woodland, Chief
 Environmental Assessment Branch
 National Marine Fisheries Service
 Southeast Region
 9830 Roger Blvd.
 St. Petersburg, Fla. 33702
 - 3) Regional Administrator
 EPA International Bldg.
 1201 Elm St.
 Dallas, Texas 75270
 - 4) Joel L. Lindsey, Administrator
 Office of Natural Resources
 Office of the Secretary
 P. O. Box 44396
 Baton Rouge, La. 70804
 - 5) James L. Isevogel, Superintendent
 Jean Lafitte Natl. Hist. Park
 c/o Municipal Auditorium
 1201 St. Peter St.
 New Orleans, La. 70116

6) National Wildlife Federation
 1412 18th St., N.W.
 Washington, D.C. 20036

Response 13.14: Soil Association Table on Page IV-25 has been corrected
 as indicated.

Response 13.15: Use of colored maps is prohibitively expensive. The text
 has been corrected on page A-1 to indicate that larger
 scale maps are available for inspection.

Response 13.16: See Response 13.6.

Response 13.17: Comment is noted.

Letter No. 14

SIERRA CLUB, DELTA CHAPTER

520 Esplanade Avenue
New Orleans, La. 70116



Colonel Robert Lee,
District Engineer US Army Corps
Attn: LKNOD-SA
POB 60267
N.C., La. 70160

Dear Colonel Lee:

Jan. 28, 1983

Thank you for the opportunity to comment on the "Terrebonne Parish-wide Forced Drainage System, Terrebonne Parish, Louisiana" DEIS.

In general we find this DEIS contains good baseline data. The habitat sections are well done; also the fisheries, the geological descriptions make for interesting reading in and of themselves. The need for this type of parish-wide project is unquestioned and the Corps is to be applauded for demanding a DEIS parish-wide rather than piece-mealing all the projects.

As large and comprehensive a document as is this DEIS, however, it is inevitable that the individual projects will not receive the detail necessary to evaluate them.

Five(5) unauthorized projects are being grandfathered in within this DEIS as a legality. Some of these are in bad locations. The Sierra Club questions the wisdom of mentioning individual projects as a group instead of assessing them individually.

Was the wetlands--non-wetlands line determined for each of these five?

Was there an environmental assessment done for these? Is this, in fact, another after-the-fact permit? After-the-fact permits are an appalling error by the Corps. Damage that is done in wetlands unlike many other situations can be undone. These five projects are hadly mentioned in this DEIS. This seems to be an oversight.

These 26 projects need to be prioritized by the parish. Some will undoubtedly never be done.

Maps. These maps are quite inadequate to allow for precisely determining the wetlands-non-wetlands interface for these projects. Differences of three to four hundred feet may occur based on these maps possibly resulting in the loss of significant acreage of wetlands.

Mitigation. These projects must be mitigated and undoubtedly will be mitigated. There is no mention of mitigation in this DEIS.



Response 14.1: The text has been corrected on Page J-1 to indicate that the 26 proposed projects may be assigned priority at the discretion of the parish after the 5 unauthorized projects has been satisfactorily resolved.

See Response 7.11.

Response 14.2: The text has been corrected on Page A-1 to indicate that larger scale maps are available for inspection.

Response 14.3: See Response 14.1.

14.1

14.2

14.3

SIERRA CLUB, DELTA CHAPTER



In sum, the Delta Chapter finds the following:

- 14.4 1. The DEIS is too general.
- 14.5 2. The levees should be kept to the wetland-non-wetland interface.
- 14.6 3. An environmental assessment of each project with detailed maps and alignments is needed.
- 14.7 4. Off-setting mitigation such as plugging abandoned canals, backfilling canals and other restorative measures must accompany a project of this nature.
- 14.8 5. Bottomlands areas, particularly around Houma, should be maintained. Certain cypress-tupelo swamps exist around Houma along with other bottomlands hardwoods. Bottomlands hardwoods are a dwindling habitat in Louisiana and the country and it is possible to keep these wetlands with proper planning to serve as a reservoir to protect existing subdivisions.
- 6. The environmental assessments for each project should also go out on public notice. There is not sufficient information in this DEIS to address each of these projects.

Response 14.4: See Response 7.4.
 Response 14.5: See Response 7.15.
 Response 14.6: See Response 14.1.
 Response 14.7: See Response 7.15.
 Response 14.8: See Response 14.1.

Sincerely yours,
Michael B. Halle
 Michael Halle, Member
 Delta Chapter Wetlands Committee



JAN 17 1993

ROBERT C. LEE
COLOMBO, CE
DISTRICT ENGINEER

Letter No. 15

SUBJ: DRAFT ENVIRONMENTAL
IMPACT STATEMENT
LINDORS-SA.

SIR:

I HAVE RECEIVED A COPY OF THE DRS
FOR RG PROPOSED AND FIVE AFTER-THE-
FACT FORCED DRAINAGE PROJECTS IN MY PARISH.
I HAVE REVIEWED THE DRS AND FOUND IT
WELL PREPARED. I URGE THE COAS OF
ENGINEERS TO ACCEPT THIS DOCUMENT AND
GRANT TERRIERME PARISH PERMIT TO BEGIN
AS-ONCE THE PROCESS TO EMPLOYMENT A
FORCED DRAINAGE SYSTEM.

ENCLOSE YOU WILL FIND PHOTOS & NEWS
PAPER CLIPPINGS THAT DEPICT THE FLOOD &
POLLUTION PROBLEMS IN MY PARISH.

THE FLOODING HAS BEEN WITH US FOR
A LONG TIME & IS GETTING WORSE, DUE
MAINLY TO LAND SUBSIDENCE. FLOODING
DOES MORE HARM TO OUR ENVIRONMENT BECAUSE
THE FLOOD WATER IS SATURATED WITH POLLUTANTS.
GOOD DRAINAGE INSIDE A FORCED DRAINAGE
AREA WOULD LESSEN POLLUTION AND COULD
BE INSTALLED EARLY. FLOODING COST US
MILLIONS OF DOLLARS EVERY YEAR IN PROPERTY DAMAGE.
GOOD DRAINAGE IS A MUST.

T. J. Lee, Chairman
600 Bayou Terrace Drive
Metairie, La. 70002

Response 15.0: Comments taken into consideration; no CDF response deemed necessary.

BIBLIOGRAPHY AND/OR LITERATURE CITED

- Adams, D.A 1963. Factors influencing vascular plant zonation in North Carolina salt marshes. *Ecology* 44: 445-456.
- Adams, J.G. and M.W. Street. 1969. Notes on the spawning and embryological development of blue-back herring. (*Alosa aestivalis* Mitchell) in the Altamaha River, Georgia. *Contrib. Series No. 16, Marine Div., Coastal Fisheries Div., Game and Fish Comm., Ga. Dept. of Natural Resources, Brunswick.*
- Adams, R.D., B.B. Barrett, T.H. Blackmon, B.W. Gane, and W.G. McIntire. 1976. Barataria basin: geologic processes and framework. Louisiana State University, Center for Wetland Resources, Baton Rouge, La. Sea Grant Publ. LSU-T-76-008.
- _____, P.J. Banas, R.H. Baumann, J.H. Blackmon, and W.G. McIntire. 1978. Shoreline erosion in coastal Louisiana; inventory and assessment. La. Dept. of Trans. and Development.
- Allen, K.R. 1951. The Horokiwi stream: a study of a trout population. *Fish Bull. N.Z.*, 10:1-238.
- Altschul, J.H. 1978. Cultural resources impact assessment: Houma-Terrebonne regional sewage plan prepared for U.S. Environmental Protection Agency, Region VI, Dallas, Texas. New World Research, New Orleans.
- Ascher, Marcia. 1959. A mathematical rationale for graphic seriation. *American Antiquity*, Vol. 25, No. 2.
- Bahr, L.M. and J.J. Hebrard. 1976. Barataria basin: biological characterization. Center for Wetland Resources, Louisiana State University, Baton Rouge, La. Sea Grant Publication No. LSU-T-76-005. 140 p.
- Bateman, H.A. 1966. Clapper rail (*Rallus longirostris*) studies on Grand Terre Island, Jefferson Parish, Louisiana. M.S. Thesis, Louisiana State University, Baton Rouge, La. 145 pp.
- Baumann, R.H. 1980. Mechanisms of maintaining marsh elevation on a subsiding environment. M.S. Thesis, Louisiana State University, Baton Rouge, La.
- _____, and R.D. Adams. 1982. The creation and restoration of wetlands by natural processes on the Lower Atchafalaya River system: possible conflicts with navigation and flood control objectives. *Proceedings Eighth Annual Conference on Wetlands Restoration and Creation, Tampa, Fl. May 8-9, 1981.*
- Bedinger, M.S. 1978. Relation between forest species and flooding. *in* P.W. Greeson, J.P. Clark and J.E. Clark, editors. *Wetland functions and values: the state of our understanding.* Amer. Water Resources Minneapolis

- Bodin, G. 1982. Pers. Comm. Telephone Conversation, Houma.
U.S. Fish and Wildlife Service, Lafayette, La. March, 1982.
- Boto, K.G. and W.H. Patricks, Jr. 1978. Role of wetlands in the removal of suspended sediments in P.E. Greeson, J.R. Clark and J.E. Clark, editors. Wetland functions and values: the state of our understanding, American Water Resources Association, Minneapolis, Minnesota.
- Boyd, C.E. 1969. Production, mineral nutrient absorption, and biochemical assimilation by Justicia americana and Alternanthera philoxeroides. Arch. Hydrobiol. 66: 139-160.
- _____ and Blackburn, R.D. 1970. Seasonal changes in the proximate composition of some common aquatic weeds. Hyacinth Control Journal 8, 42-44.
- Bragg, Marion. 1977. Historic names and places on the lower Mississippi River. Mississippi River Commission, Vicksburg.
- Bull, J. and J. Farrand, Jr. 1977. The Audubon Society field guide to North American Birds. Alfred A. Knopf, Inc. New York. 775 pp.
- Burk and Associates, Inc. 1976. Unique ecological features of the Louisiana coast. State Planning Office, Coastal Resources Program, Baton Rouge, La.
- Buttery, B.R., W.T. Williams, and J.M. Lambert. 1965. Competition between Glyceria maxima and Phragmites communis in the region of Surlurgham Broad. J. Ecol. 53, 183-195.
- Byrd, K.M. 1972. An archaeological assessment of Bayous Boeuf, Black and Chene project area. Unpublished report in the files of the Louisiana Division of Archaeology and Historic Preservation, Baton Rouge.
- Byrne, P., M. Borengasser, G. Drew, R. Miller, B.L. Smith, Jr. and C. Wax. 1976. Barataria basin: hydrologic and climatologic processes. Louisiana State University, Center for Wetland Resources, Baton Rouge, La. Sea Grant Publ. LSU-T-76-010.
- Chabreck, R.H. 1980. Freshwater inflow and saltwater barriers for management of coastal wildlife and plants in Louisiana. in R. Cross and D. Williams, editors. 1981. Proceedings of the national symposium on freshwater inflow to estuaries. U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-81/04. 2 Vol.
- _____, 1981. Pers. Comm. Telephone Conversation, Baton Rouge. Louisiana State University, School of Forestry and Wildlife Management, April, 1981.
- _____, 1972. Vegetation, water, and soil characteristics of the Louisiana coastal region. Louisiana State University Agr. Exp. Sta. Bull No. 664
- _____ and G. Linscombe. 1978. Vegetative type map of the Louisiana coastal marshes. Louisiana Wildlife and Fisheries Commission. Baton Rouge.

- Chabreck, R.H. and R.E. Condrey. 1979. Common vascular plants of the Louisiana marsh. Louisiana State University Center for Wetland Resources, Baton Rouge, La. Sea Grant Publication No. LSU-T-79-003.
- _____, T. Joanen, and A.W. Palmisano. 1968. Vegetative type map of the Louisiana coastal marshes. Louisiana Department of Wildlife and Fisheries, New Orleans, La.
- Coastal Engineering Research Center (CERC). 1973. Shore protection manuals. Vols. I and II.
- Coastal Environments, Inc. 1974. Environmental planning base, Terrebonne Parish, Louisiana. Coastal Environments, Inc., Baton Rouge.
- Coastal Environments, Inc. no date. Terrebonne Parish habitats 1978. Map Scale 1:100,000. Coastal Environments, Inc., Baton Rouge, La.
- Coleman, J.M. 1966. Recent coastal sedimentation: central Louisiana coast. Coastal Studies Institute, Tech. Rept. No. 79 LSU.
- _____ and S.M. Gagliano. 1964. Cyclic sedimentation in the Mississippi River deltaic plain. Gulf Coast Assoc. Geol. Soc., Trans.
- _____ and W.G. Smith. 1964. Late recent rise of sea level, Geol. Soc. Amer. Bull., V. 75.
- Collins, H.B. 1927. Archaeological work in Louisiana and Mississippi. in Explorations and field-work of the Smithsonian Institution in 1926. Smithsonian Miscellaneous Collections, Vol. 7, No. 7.
- Conner, W.H., J.G. Gosselink and R.T. Parrondo. 1981. Comparison of the vegetation of three Louisiana swamp sites with different flooding regimes. Am. J. Bot., 68:320-331.
- _____ and J.W. Day, Jr. 1976. Productivity and composition of a baldcypress-water tupelo site and a bottomland hardwood site in a Louisiana swamp. Amer. J. Bot. 63 (10): 1354-1364.
- Cowardin, L.M., F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service Biological Services Program. FWS/OBS-79/31. 103 pp.
- Cowgill, G.L. 1968. Review of computer analysis of chronological seriation, by F. Hole and M. Shaw. American Antiquity, Vol. 33. 517-519.
- Cox, Huppenbauer and Osborne, Attorneys and Counselors at Law. 1980. Statistical presentation of revenue and debt structure, Terrebonne Parish. New Orleans, Louisiana.
- Craig, N.J., and J.W. Day, Jr., eds. 1977. Cumulative impact studies in the Louisiana coastal zone: eutrophication and land loss. Final report to Louisiana State Planning Office, Baton Rouge. 85 pp.
- Craig, N.J., R.E. Turner, and J.W. Day, Jr. 1979. Land loss in coastal Louisiana. Journal of Environ. Manag., Vol. 3, No. 1.

- Cummins, K.W. and G.L. Spengler. 1978. Stream ecosystems. *Water Spectrum* (Fall). 1-9 pp.
- Curry, J.R. 1965. Late Quaternary history, continental shelves of the United States. in H.F. Wright, Jr. and D.G. Frey, editors. *The quaternary of the United States*, Princeton University Press.
- Czajowski, Richard. 1934. Preliminary report of archaeological excavations in Orleans Parish. *Louisiana Conservation Review*. Vo. 4, No. 3.
- Darnell, R.M. 1958. Food habits of fishes and larger invertebrates of Lake Pontchartrain, Louisiana, an estuarine community. *Publ. Texas Inst. Mar. Sci.* 5:353-416.
- _____. 1961. Trophic spectrum of an estuarine community based on studies of Lake Pontchartrain, La. *Ecology*, 42(3): 553-568.
- Davis, D.W. 1981. Land use patterns related to the development of Louisiana's coastal oil and gas industry. Unpubl. manuscript, Nicholls State University, Thibodaux, Louisiana.
- _____. 1973. Louisiana canals and their environmental influence on wetland development. Unpubl. Ph.D. dissertation, Louisiana State University, Baton Rouge.
- _____. 1976. Shrimp drying, ancient art. *Aquanotes* 5(3): 1,2,6.
- _____. 1978. Wetland trapping in Louisiana. in S.B. Hillard, editor. *Man and environment in the lower Mississippi valley*. pp. 81-92. School of Geoscience, Louisiana State University, Baton Rouge.
- _____. and R.A. Detro 1977. Land-use research, one approach to coastal settlement. in H.J. Walker, editor. *Research techniques in coastal environments*, pp. 311-320. School of Geoscience, Louisiana State University, Baton Rouge.
- Day, J.W., T.J. Butler, and W.H. Conner. 1977. Productivity and nutrient export studies in a cypress swamp and lake system in Louisiana. Pages 255-269 in M. Wiley (ed.), *Estuarine Processes*. Vol. II: Academic Press, New York. 428 pp.
- _____, W.G. Smith, P.R. Wagner and W.C. Stowe. 1973. Community structure and carbon budget of a salt marsh and shallow bay estuarine system in Louisiana. Louisiana State University, Center for Wetland Resources, Baton Rouge, La.
- de la Cruz, A.A. 1978. Production and transport of detritus in wetlands, p. 162-174. in P.E. Greeson, J.R. Clark and J.E. Clark, editors. *Wetlands functions and values: the state of our understanding*. Proc. of the National Symposium on Wetlands. American Water Resources Association, Minneapolis, Minnesota.
- _____. 1980. Recent advances in our understanding of salt marsh ecology. Pages 51-65. in P.L. Fore and R.D. Peterson, editors. *Proc. of the Gulf of Mexico coastal ecosystems workshop*. U.S. Fish and Wildlife Serv., Albuquerque, New Mexico.

- de la Cruz, A.A. 1973. The role of tidal marshes in the productivity of coastal waters. Assoc. Southeast. Biol. Bull 20: 147-156.
- _____, A.A. and H. Kawanabe. 1967. The population and food habits of fish in a small estuarine pond. Nat. Appl. Sci. Bull. 20: 473-477.
- Delaune, R.D., W.H. Patrick, Jr. and J.M. Brannon. 1976. Nutrient transformations in Louisiana salt marsh soils. Louisiana State University Center for Wetland Resources, Baton Rouge, La. Sea Grant Publication No. LSU-T-76-009.
- _____, W.H. Patrick, Jr. and R.J. Buresh. 1978. Sedimentation rates determined by ¹³Cs dating on a rapidly accreting salt marsh. Nature 275: 532-533.
- Dept. of Experimental Statistics. 1981. State Data Center Newsletter (January), Louisiana State University, Baton Rouge.
- Detro, R.A. and D.W. Davis. 1978. Bayou Lafourche in R.H. Kesel and R.A. Saudar, editors. A field guidebook for Louisiana. Association of American Geographers, Washington, D.C.
- Dickson, J.G. 1978. Seasonal bird populations in a south central Louisiana bottomland hardwood forest. J. Wildl. Manage. 42(4): 875-883.
- Dyer, J.O. 1917. The Lake Charles Atakapas period, 1817 to 1820. Howard Memorial Library. New Orleans.
- Elliott, D.O. 1932. Improvement of the lower Mississippi River for flood control and navigation. Vol. 1. Vicksburg, Miss.
- Environmental Protection Agency. 1979. Region IV, Louisiana coastal inventory, October 1978. Office of Research and Development, USEPA, Las Vegas, Nevada. EMSL-LV Project RSD 7870. Vols. 5-8.
- Evans, O. 1963. Melting pot in the bayous. American Heritage 15(1): 30-51.
- Farfante, I.P. 1969. Western Atlantic shrimps of the genus Penaeus. U.S. Fish and Wildlife Service, Fish. Bull., 67:461-591.
- Fisk, H.N. 1952. Geological investigations of the Atchafalaya Basin and the problem of Mississippi River diversion. U.S. Army Corps of Engineers, Mississippi River Comm., Vicksburg, Mississippi.
- _____, E. McFarlan, Jr., C.R. Kolb and L.F. Wilbert, Jr. 1954. Sedimentary framework on the modern Mississippi delta. Journal Sed. Petrol.
- Ford, J.A. 1936. Analysis of Indian village site collections from Louisiana and Mississippi. Louisiana Geological Survey, Anthropological Study 2, Dept. of Conserv. New Orleans.
- _____. 1951. Greenhouse: A Troyville-Coles Creek period site in Avoyelles Parish, Louisiana. Museum of Natural History, Anthropological Papers, Vol. 44, Part 1.

- _____ and C. Webb. 1956. Poverty Point: a late Archaic site in Louisiana. American Museum of Natural History, Anthropological Papers, Vol. 46, Part 1.
- _____ and G.I. Quimby, Jr. 1945. The Tchefuncte culture, an early occupation of the lower Mississippi valley. Society for American Archaeology, Memoir No. 2.
- _____ and G. Willey. 1940. Crooks site, a Marksville period burial mound in LaSalle Parish, Louisiana. La. Dept. of Conserv., Anthropological Study No. 3.
- Foreman, L.M. 1982. Pers. Comm. City of Houma Dept. of Planning Progr. and Community Devel. Houma, La.
- Foreman, W.W. 1968. Ecological survey of Lake Grande Ecaille, Louisiana. Freeport Sulphur Co., Belle Chasse, La.
- Foster, J.W. 1873. Prehistoric races of the United States of America. S.C. Griggs and Company, Chicago.
- Fortier, A. editor. 1909-14. Louisiana, comprising sketches of counties, towns, events, institutions and persons arranged in cyclopedic form. 2 vols.
- Frazier, D.E. 1967. Recent deltaic deposits of the Mississippi River: their development and chronology. Gulf Coast Assoc. Geol. Soc. Trans.
- Frazier, J. editor. 1981. Directory of Manufactures. La. Dept. of Commerce, Baton Rouge, La.
- Frederickson, L.H. 1979. Floral and faunal changes in lowland hardwood forests in Missouri resulting from channelization, drainage and impoundment. U.S. Fish and Wildlife Serv. FWS/OBS-78/91. 130 pp.
- Gael, B.T. and C.S. Hopkinson. 1979. Drainage density, land use and eutrophication in Barataria Bay, Louisiana. Pages 147-165 in J.Q. Day, Jr., D. Curley, R.E. Turner and A. Mumphrey, editors. Third coastal marsh and estuary management symposium. Louisiana State University, Div. of Cont. Ed., Baton Rouge. 511 p.
- Gagliano, S.M. 1963. A survey of preceramic occupations in portions of south Louisiana and south Mississippi. Florida Anthropologist, Vol. 16, No. 4. 105-132.
- _____. 1967. Occupation sequence at Avery Island. Louisiana State University, Coastal Studies Series, No. 22.
- _____ and J.L. van Beek. 1970. Geologic and geomorphic aspects of deltaic processes. Mississippi delta system. Hydrologic and geologic studies of coastal Louisiana, Rept. No. 1, Louisiana State University Coastal Studies Inst., and Dept. Marine Sciences.
- _____, Klaus J. Meyer-Arendt, and Karen Wicker. 1981. Land loss in the Mississippi River deltaic plain. Gulf Coast Assoc. of Geol. Soc., Transactions.

- _____, R.F. Weinstein and E.K. Burden. 1975. Archaeological investigations among the Gulf Intracoastal Waterway. Coastal Louisiana area report submitted to the U.S. Army Corps of Engineers, New Orleans.
- _____ and R.T. Saucier. 1963. Poverty Point sites in southeastern Louisiana. *American Antiquity*. Vol. 28. 320-327.
- Galtsoff, P. 1964. The American oyster, *Crassostrea virginica* Gmelin, U.S. Fish Bull. 64. 480p.
- Gannon, P.T., Sr., J.F. Bartholic and R.G. Bill, Jr. 1978. Climatic and meteorological effects of wetlands. in P.E. Greeson, J.R. Clark and J.E. Clark, editors. *Wetland functions and values: the state of our understanding*. Amer. Water Resources Assoc., Minneapolis, Minnesota p. 576-588.
- Gatschet, A.S. 1883. The Shetimasha Indians of St. Mary Parish, southern Louisiana. Transcript of the Anthropological Society of Washington, Vol. 2. 148-158.
- Gibson, J.L. 1975. Archaeological survey of Bayou Teche, Vermillion River and Freshwater Bayou, south central Louisiana. The University of Southwestern Louisiana, Center for Archaeological Studies No. 2.
- _____. 1974. Poverty Point: the first American chiefdom. *Archaeology*, Vol. 27, No. 2. 97-105.
- _____. 1975. The prehistory of Acadiana. in S.L. DeSoto and J.L. Gibson, editors. *The culture of Acadiana: tradition and change in south Louisiana*. 16-40. University of Southwestern Louisiana, Lafayette.
- _____. 1974. The Tchefoncté culture in the Bayou Vermilion Basin, south central Louisiana: a developmental case study. *Bulletin of the Texas Archaeological Society* 45: 67-95, Austin.
- Godden, G.A. 1964. *Encyclopedia of British pottery and porcelain marks*. Bonanza Books, New York.
- Gordon, Pat. 1982. Personal correspondence, Terrebonne Parish Department of Public Works Reports of Building Permits Issued and Local Public Construction. Houma, La.
- Gorham, E. 1957. The development of peat lands. *Quart. Rev. Biol.* 32, 145-166.
- Gosselink, J.G., C.L. Cordes and J.W. Parsons. 1979. An ecological characterization study of the chenier plain coastal ecosystem of Louisiana and Texas. 3 vols. U.S. Fish and Wildlife Service, Office of Biological Services.
- _____, C.S. Hopkinson, Jr., and R.T. Parrondo. 1977. Marsh plant species, Gulf Coast area. Volume I. "Production marsh vegetation." U.S. Army Corps of Engineers Tech. Rept. D-77. Louisiana State University, Center for Wetland Resources, Baton Rouge, La.

- _____ and R.E. Turner. 1978. The role of hydrology in freshwater wetland ecosystems. in R.E. Good, D.F. Whigham and R.L. Simpson, editors. Fresh water wetlands: ecological processes and management potential Academic Press, New York, p. 63-78.
- Gould, H.R. 1970. The Mississippi Delta complex. Reprint from deltaic sedimentation, modern and ancient. Soc. of Econ. Pal. and Min., Sp. Publ. 15.
- Gregory, H.F. and C.H. Webb. 1975. Chitamacha basketry. Louisiana Archaeology, No. 2, 23-39.
- Gunter, G. 1967. Some relationships of estuaries to the fisheries of the Gulf of Mexico, p. 621-638. in G.H. Lauff, editor. Estuaries, Publ. No. 83. Amer. Assoc. for the Advancement of Sci., Washington, D.C.
- Haag, W.G. 1965. Louisiana in north American prehistory. Louisiana Studies. 4: 279-323. Natchitoches.
- Hellier, T.R., Jr. 1962. Fish production and biomass studies in relation to photosynthesis in the Laguna Madre of Texas. Publ. Inst. Mar. Sci., Univ. of Tex., 8: 1-22.
- Hicks, S.D. 1978. An average geopotential sea level series for the United States. J. of Geophysical Research 83(C3): 1377-1379.
- _____. 1981. Long-period sea level variations for the United States through 1978, Shore and Beach 49(2): 26-29.
- _____. 1968. Long-period variations on secular sea level trends. Shore and Beach 36(1): 32-36.
- _____. 1972. On the classification and trends of long period sea level series. Shore and Beach 40(1): 20-23.
- Hildebrand, S.F. 1954. A study of the fauna of the brown shrimp (Penaeus aztecus Ives) grounds in the western Gulf of Mexico. Publ. Inst. Mar. Sci., Univ. of Texas, 3(2): 233-366.
- Hinde, H.P. 1954. Vertical distribution of salt marsh phanerogams in relation to tide levels. Ecol. Monogr. 24, 209-225.
- Hood, M.A., and S.P. Meyers. 1976. Microbiota. Vol. III, App. VI., Sec. 5, in J.G. Gosselink, R.R. Miller, M. Hood, and L.M. Bahr, Jr., editors. Louisiana offshore oil port: environment baseline study. LOOP, Inc., Baton Rouge, Louisiana.
- Hopkinson, C.S., Jr. and J.W. Day, Jr. 1980. Modeling the relationship between development and storm water and nutrient runoff. Environmental Management, Vol. 4, No. 4, pp. 315-324.
- Houma-Terrebonne Chamber of Commerce. August 1981. Houma-Terrebonne Statistical Information.
- Howe, H.V. and C.K. Moresi. 1931. Geology of Iberia Parish, La. Dept. Consv. Geol. Bull. No. 1.

- Hupp, G., J.G. Gosselink, and J.W. Day, Jr. 1977. The seasonal distribution of organic carbon in a Louisiana estuary. *Est. and Coastal Mar. Sci.* 5: 695-705.
- Jacobs, J. 1975. Diversity, stability, and maturity in ecosystems influenced by human activities. in W.H. van Dobben and R.H. Lowe-McConnel, editors. *Unifying concepts in ecology*. Dr. W.J.B.V. Publishers, The Hague. pp. 187-207.
- _____ and H. Loesch. 1971. A preliminary two year comparison of Panaeus aztecus growth rate, distribution, and biomass in the Barataria Bay area, Louisiana. *Coastal Studies Bull.*, 6: 45-55.
- J.H. Stone, ed. 1980. Environmental analysis of Lake Pontchartrain, Louisiana, its surrounding wetlands, and selected land uses. CEL, CWR, LSU, B.R., La. 70803. Prepared for U.S. Army Engineer District, New Orleans. Contract No. DACW29-77-C-0253.
- Jones, R.S., W. Ogletree, J. Thompson, and W. Flennilsen. 1963. Helicopter borne purse net for population sampling of shallow marine bays. *Publ. Inst. Mar. Sci., Univ. of Texas*, 9: 1-6.
- Kemp, G.P. 1978. Agricultural runoff and nutrient dynamics of a swamp forest in Louisiana. M.S. thesis, Louisiana State University, Baton Rouge. 57 pp.
- Kinler, N.W., Linscombe, G. and R.H. Chabreck. 1981. Smooth beggartick: its distribution, control, and impact on nutria in coastal Louisiana. *Proceedings Worldwide Furbearer Conf.* Frostburg, Md. August, 1980.
- Kirby, C.J. and J.G. Gosselink. 1976. Primary production in a Louisiana Gulf Coast Spartina alterniflora marsh. *Ecology* 57: 1051-1059.
- Klopatek, J. 1978. Nutrient dynamics of a freshwater riverine marsh and the role of emergent macrophytes. in R.E. Good, D.F. Whigam and R.L. Simpson, editors. *Freshwater wetlands: ecological process and management potential*. pp. 195-216. Academic Press, New York.
- _____. 1975. The role of emergent macrophytes in mineral cycling in a freshwater marsh. in F.G. Howel, J.B. Gentry and H.M. Smith, editors. *Mineral cycling in southeastern ecosystems*. pp. 367-393. ERDA Symposium Series (CONF-740513).
- Kniffen, F.B. 1936. A preliminary report on the Indian mounds and middens of Plaquemines and St. Bernard parishes. *La. Geol. Surv., Geol. Bull.* 8, La. Dept. of Consv., New Orleans.
- _____. 1938. Indian mounds of Iberville Parish, in Reports on the geology of Iberville and Ascension parishes. *La. Geol. Surv., La. Dept. of Conser., Geol. Bull.* 13.
- _____. 1975. Louisiana's historic Indians. *Louisiana Archaeology* No. 2.
- _____. 1968. Louisiana, its land and people. La. State Univ. Press, Baton Rouge.

- Kolb, C.R. and J.R. Van Lopic. 1958. Geology of the Mississippi deltaic plain, southeastern Louisiana. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Miss., Tech. Rept. 3-483, 2 Vols.
- Kutkuhn, J.H. 1962. Gulf of Mexico commercial shrimp populations, trends and characteristics, 1956-59. U.S. Fish and Wild. Serv. Fish. Bull. 62: 343-402.
- Kwon, H.J. 1969. Barrier islands off the northern Gulf of Mexico coast: sediment source and development. Tech. Rept. 75, Coastal Studies Institute, Louisiana State University, Baton Rouge.
- Lambou, V.W. 1959. Fish populations of backwater lakes in Louisiana. Trans. Amer. Fish Soc. 88(1): 7-15.
- Landenburg, R. 1972. Man, oil and the sea. Offshore 32(11): 54-79.
- Lantz, K. 1970. An ecological survey of factors affecting fish production in a Louisiana natural lake and river. La. Wildlife and Fisheries Comm. Bull. #6, New Orleans, 92 pp.
- Larson, D.K., D. Davis, R. Detro, P. Dumond, E. Liebow, R. Motschall, D. Sorensen, and W. Guidroz. 1980. Mississippi deltaic plain region ecological characterization: a socioeconomic study. Vol. 1. Synthesis papers. U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-79/05
- _____, D. Davis, R. Detro, and P. Dumond. 1979. Mississippi deltaic plain region ecological characterization: a socioeconomic study, (3 vols.); prepared for Biological Services Program, U.S. Fish and Wildlife Service. Wildan Associates, Phoenix, Arizona.
- _____, D. Davis, R. Detro, P. Dumond, E. Liebow, R. Motschall, D. Sorensen, and W. Guidroz. 1980. Mississippi deltaic plain region ecological characterization: a socioeconomic study. Vol. III Maps. U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-79/05.
- Larson, L.H., Jr. 1972. Functional considerations of warfare in the south-east during the Mississippi period. American Antiquity, Vol. 37. 383-392.
- Leslie, J.P., Jr. 1980. Cultural resource architectural survey of Terrebonne Parish, Louisiana. Unpubl. manuscript, La. Div. of Archaeology and Historic Preservation, Baton Rouge.
- Lindall, W.N., J. Hall, J.E. Sykes and E.L. Arnold. 1972. Louisiana coastal zone: analysis of resources and resource development needs in connection with estuarine ecology. Sections 10 and 13--Fishery Resources and their needs. Report of the Commercial Fishery Work Unit. National Marine Fisheries Service Biol. Lab., St. Petersburg Beach, Florida.
- Lindsey, A.A., R.O. Petty, D.V. Sterling and W. Van Asdall. 1961. Vegetation and environment along the Wabash and Tippecanoe Rivers. Ecol. Monogr. 31 (2): 105-156.

- Livingston, R.J. and O.L. Loucks. 1978. Productivity, trophic interactions, and food-web relationships in wetlands and associated systems, p. 101-119. in P.E. Greeson, J.R. Clark and J.E. Clark, editors. Wetlands functions and values: the state of our understanding. Proc. of the National Symposium on Wetlands. American Water Resources Association, Minneapolis, Minnesota.
- Lock, M.A. and H.B.N. Hynes. 1976. The fate of "dissolved" organic carbon derived from autumn-shed leaves (Acer saccharum) in a temperate hard water stream. *Limnol. Oceanogr.* 21(3): 436-443.
- Louisiana Dept. of Labor. 1980. Printouts on covered employment and total wages paid, 4-digit industry codes in Terrebonne parish for the 4th quarter of 1979. 4 pp.
- Louisiana Tax Commission. 1980. Nineteenth Biennial Report Moran Industries, Inc. Baton Rouge, La. 177 pp.
- LSU Cooperative Extension Service. no date. Agricultural Summary Louisiana, 1979. Louisiana State University. 69 pp.
- LSU Cooperative Extension Service. no date. Agricultural Summary Louisiana, 1980. Louisiana State University. 84 pp.
- Louisiana State Planning Office. 1975. Land use and data analysis program. U.S. Geological Survey 1972.
- Louton, J.H. and R.W. Bouchard. 1976. Insects. Vol. III, App. VI, Sec. 9 in J.G. Gosselink, R.R. Miller, M. Hood, and L.M. Bahr, Jr., editors. Louisiana offshore oil port: environmental baseline study. LOOP, Inc., New Orleans, Louisiana.
- Lowery, G.H. 1974. Louisiana birds. Louisiana State University Press, Baton Rouge. 651 pp.
- Lush, D.L. and H.B.N. Hynes. 1973. The formation of particles in freshwater leacheates of dead leaves. *Limnol. Oceanogr.* 18(6): 968-977.
- _____ and H.B.N. Hynes. 1978. The uptake of dissolved organic matter by a small spring stream. *Hydrobiologia*, 60(3): 271-275.
- Marmer, H.H. 1952. Changes in sea level determined from tide observations: in Proc. Zd. Conf. on coastal engineering. Council on Wave Research, Univ. of Calif., Berkeley California.
- _____. 1954. Tides and sea level in the Gulf of Mexico, p. 101-118. in Gulf of Mexico, its origin, waters and marine life, U.S. Fish and Wildlife Serv. Fishery Bull. 89.
- Martin, A.C. and C.M. Uhler. 1939. Food of game ducks in the United States and Canada. Res. Report 30, USDA Tech. Bull. 634. (Reissued as a reprint in 1951 by the Fish. & Wildl. Serv., USDI).
- Maruggi, V. and S.D. Hartl, editors. 1981. Statistical abstract of Louisiana. Univ. of N.O. Div. of Business and Econ. Research and the Louisiana State Planning Office. 413 pp.

- Mason, C.F. and R.J. Bryant. 1975. Production, nutrient content, and decomposition of Phragmites communis Trin and Typha augustifolia L.J. Ecol. 63, 71-96.
- McEwen, R.W. Mosco, and V. Carter. 1976. Coastal wetland mapping. Photogrammetric, Engineering and Remote Sensing 42(2): 221-232.
- McIntire, W.G. 1954. Correlation of cultural remains with the physical setting. Coastal Geog. Conference, Washington, D.C., ONR.
- _____. 1971. Methods of correlating cultural remains with stages of coastal development. Coastal Geomorphology, the McMillan Company, London.
- _____. 1958. Prehistoric Indian settlements of the changing Mississippi River delta, LSU Studies, Coastal Studies Series No. L, Baton Rouge.
- _____ and Clara Ho. 1969. Development of barrier island lagoons: western Gulf of Mexico, coastal lagoons. Universidad Nacional Autonoma de Mexico.
- Meighan, C.W. 1959. A new method for the seriation of archaeological collections. American Antiquity, Vol. 25, No. 2, 203-211.
- Morgan, D.J. 1977. The Mississippi River delta: legal-geomorphologic evaluation of historic shoreline changes. Vol. XVI, Geoscience and Man, Louisiana State Univ., School of Geoscience, Baton Rouge, La.
- Morgan, J.P. 1970. Deltas, a resume. Jour. Geological Education, Vol. 18.
- _____. 1973. Impact of subsidence and erosion on Louisiana coastal marshes and estuaries. Coastal Marsh and Estuary Symposium, Baton Rouge, Louisiana.
- _____. 1974. Recent geological history of the Timbalier Bay area and adjacent continental shelf. Melanges, No. 9, Louisiana State Univ., Museum of Geoscience, Baton Rouge, La.
- _____ and P.B. Larimore. 1957. Changes in the Louisiana shoreline. Transactions of the Gulf Coast Assoc. Geological Societies, Vol. 7.
- Morris, A.W., R.P.C. Mantoura, A.J. Bale and R.J.M. Howland. 1978. Very low salinity regions of estuaries: important sites for chemical and biological reactions. Nature 274. pp. 678-680.
- Neuman, R.W. 1977. An archaeological assessment of coastal Louisiana. Melanges II, Baton Rouge.
- _____. 1974. An archaeological survey of the Houma Navigation Canal and Bayous LaCarpe, Terrebonne, Petit Caillou and Grand Caillou, Terrebonne Parish, Louisiana. unpubl. manuscript.
- _____. 1974. An archaeological survey of the west fork of Bayou Lacassine watershed. Unpubl. manuscript.

- Newbould, P.J. 1960. Report on the ecology of Hartland bog and fen, Dorset, given to the British Ecological Society, *J. Ecol.* 48, 762.
- Newsom, J.D. 1971. Unpublished data on wading bird populations in Barataria Bay, La. Cooperative Wild. Research Unit., Louisiana State Univ., Baton Rouge, La.
- Odum, W.E. 1970. Pathways of energy flow in a south Florida estuary. Ph.D. dissertation, Univ. of Miami, Miami, Florida, 161 pp.
- O'Neil, T. 1949. The muskrat in Louisiana coastal marshes. *La. Wildlife and Fisheries Comm.*, Tech. Rept. 28 pp.
- Owen, M.H. 1955. The oyster industry of Louisiana. Manuscript, LWFC, Div. of Oysters, Water Bottoms, and Seafoods, New Orleans. 387 pp.
- Owen, R. 1863. On the deposit of rock salt at New Iberia, Louisiana. *St. Louis Acad. Sci., Trans.*, Vol. 2.
- Paerl, H.W. 1974. Bacterial uptake of dissolved organic matter in relation to detrital aggregation in marine and freshwater systems. *Limnol. Oceanogr.* 19(6): 966-972.
- Palmisano, A.W. 1972. The distribution and abundance of muskrats (Ondatra zibethicus) in relation to vegetative types in Louisiana coastal marshes. Proceedings 26th Annu. Conf. Southeast Assoc. Game Fish Comm.
- Palmisano, W. 1971. Unpublished data on fur animals collected by the Louisiana Wildlife and Fisheries Comm., Baton Rouge, La.
- Peacock, J.S. and J. Carrighan. 1851. Historical and statistical collections of Louisiana. *De Bow's Review*, Vol. II.
- Penfound, W.T. 1952. Southern swamps and marshes. *Bot. Rev.* 18: 413-446.
- _____ and E.S. Hathaway. 1938. Plant communities in the marshlands of southeastern Louisiana. *Ecological Monographs* 8: 1-56.
- Perret, W.S. 1967. Occurrence, abundance, and size distribution of the blue crab, Callinectes sapidus, taken with otter trawl in Vermilion Bay, Louisiana, 1964-65. *Proc. La. Acad. Sci.*, 30: 63-69.
- Perret, W.S., B.B. Barrett, W.R. Latapie, J.F. Pollard, W.R. Mock, B.G. Adkins, W.J. Gaidry, C.J. White. 1971. Cooperative Gulf of Mexico estuarine inventory and study, Louisiana. Phase I, Area Description, and Phase IV, Biology, *La. Wildlife and Fish. Comm.* 175 pp.
- Peterson, R.T. 1980. A field guide to the birds east of the Rockies. Houghton Mifflin Company, Boston, Mass. 384 pp.
- Phillips, P. 1970. Archaeological survey in the lower Yazoo Basin, Mississippi, 1949-1955. *Papers of the Peabody Museum of Archaeology and Ethnology* 60, Harvard Univ., Cambridge.

- _____, J.A. Ford and J.B. Griffin. 1951. Archaeological survey in the lower Mississippi alluvial valley 1940-1947. Papers of the Peabody Museum of Archaeology and Ethnology, Vol. 25.
- Postgate, J.C. 1949. History and development of swamp and marsh drilling operations. Oil and Gas Journal 47(48): 87.
- Prentki, R., Gustafson, T. and Adams M. 1978. Nutrient movement in lake-shore marshes. in R.E. Good, D.F. Whigham and R.L. Simpson, editors. Freshwater wetlands: ecological processes and management potential. pp. 169-194. Academic Press, New York.
- Pridgeon, A.M. and L.E. Urbatsch. 1977. Contributions to the flora of Louisiana. II. Distribution and Identification of the Orchidaceae. Castena 42: 293-304.
- Pritchard, W., F.B. Kniffen and C. Brown, editors. 1945. Southern Louisiana and southern Alabama in 1819: The journal of James Leander Cathcart. The Louisiana Historical Quarterly 28: 3.
- Quimby, G.I., Jr. 1957. The Bayou Goula site, Iberville Parish, Louisiana. Fieldiana, Anthropology Vol. 47, No. 2.
- _____. 1951. The Medora site, West Baton Rouge Parish, Louisiana. Field Museum of Natural History, Anthropological Series, Vol. 24, No.2.
- _____. 1942. The Natchezan Culture Type. American Antiquity, Vol. 7 255-318.
- Rehder, J.B. 1971. Sugar plantation settlements of southern Louisiana: a cultural geography. Unpubl. Ph.D. dissertation, Louisiana State University, Baton Rouge.
- Ricker, W.E. 1946. Production and utilization of fish populations. Ecol. Monogr., 16: 374-391.
- Rivet, P.G. 1974. Archaeological survey of the Intracoastal Canal Bridge and approaches, Louisiana route 315, Terrebonne Parish. Unpubl. report in files of La. Division of Archaeology and Historic Preservation, Baton Rouge.
- _____. 1976. Cultural resources assessemnt of central St. Bridget highway, La. route 311, Terrebonne Parish. Unpubl. report in files of La. Division of Archaeology and Historic Preservation, Baton Rouge.
- Russel, R.J. 1942. Flotant. Geogr. Rev. 32: 74-98.
- _____. 1938. Physiography of Iberville and Ascension parishes. La. Dept. of Cons., Geol. Surv. Bull 13.
- _____. 1936. Physiography of the lower Mississippi River delta. Louisiana Geological Survey, Lower Mississippi Delta Geological Bulletin, Vol. 8.

- _____. 1940. Quarternary history of Louisiana. Bull. of the Geol. Soc. of Am. Vol. 51.
- Sasser, C.E. 1977. Distribution of vegetation in Louisiana coastal marshes as response to tidal flooding. M.S. thesis, Louisiana State University, Baton Rouge, La.
- Saucier, R.T. 1974. Quarternary geology of the lower Mississippi valley. Arkansas Archaeological Survey, Research Series No. 6.
- _____. 1963. Recent geomorphic history of the Pontchartrain Basin. Louisiana State University, Coastal Studies Series, No. 9.
- Scruton, P.C. 1960. Delta building and the deltaic sequence. in Recent sediments, northwest Gulf of Mexico. Amer. Assoc. Petrol. Geol., Tulsa, Oklahoma.
- Seaton, A.M. 1979. Nutrient chemistry in the Barataria Basin: a multivariate approach. M.S. thesis, Louisiana State University, Baton Rouge. 78 pp.
- Sepers, A.B.J. 1977. The utilization of dissolved organic compounds in aquatic environments. Hydrobiologia 52(1): 33-38.
- Smalley, A.E. 1958. The role of two invertebrate populations, Littorina irrorata and Orchelimum fidicinium, in the energy flow of a salt marsh ecosystem. Doctoral thesis. Univ. of Ga., Athens, Ga. 135 pp.
- Spaulding, A.C. 1953. Statistical techniques for the discovery of artifact types. Am. Antiquity, Vol. 18. 3-5-313.
- Speck, F.G. and R.W. Dexter. 1946. Molluscan food habitats of the Houma Indians. The Nautilus, Vol. 60.
- Springer, J.W. 1973. The prehistory and cultural geography of coastal Louisiana. Ph.D dissertation, Dept. of Anthropology, Yale Univ., New Haven.
- Stains, H.J. 1956. The raccoon in Kansas: natural history, managment, and economic importance. State Biol. Survey, Univ. of Kansas, Lawrence, Kansas. 76 p.
- St. Amant, L.S., J. Broom and T.B. Ford. 1965. Studies of the brown shrimp, Penaeus aztecus, in Barataria Bay, Louisiana, 1962-1965. Proc. Gulf and Carib. Fish. Inst., 18: 1-16.
- _____, V. Friedrichs, and E. Hajdu. 1957. Oysters, Waterbottoms and Seafoods Division (Biological Division). Seventh Biennial Report of the Louisiana Wildlife and Fisheries Comm., 1956-57. pp.78-81.
- Stanton, M.E. 1971. The Indians in the Grand Caillou-Dulac community. Unpubl. masters thesis, Dept. of Geogr. and Anthropology, Louisiana State Univ., Baton Rouge.

- Stone, J.H. Bahr, L.M. and J.W. Day, Jr. 1978. Effects of canals on freshwater marshes in coastal Louisiana and implications for management. in Ralph E. Good, Dennis F. Whigham and Robert L. Simpson, editors. Freshwater wetlands: ecological processes and management potential. Academic Press, Inc., New York. 378 pp.
- Stowe, W.C. 1972. Community structure and production of the epiphytic algae in the Barataria Bay area of Louisiana. Ph.D. dissertation, Louisiana State Univ., Baton Rouge, La.
- Stuewer, F.W. 1943. Raccoons: their habits and management in Michigan. Ph.D. thesis, Univ. of Michigan, East Lansing.
- Swadesh, M. 1946. Chitimacha in linguistic structures of native America. Harry Hoijer, ed., Viking Fund Publications in Anthropology, 6: 312-336. New York.
- _____. 1934. The phonetics of Chitimacha. Language, Vol. X, 4: 345-362.
- Swanson, R.L. and C.I. Thurlow. 1973. Recent subsidence rates along the Texas and Louisiana coasts as determined from tide measurements. Jour. Geophysical Res.
- Swanton, J.R. 1911. Indian tribes of the lower Mississippi valley and adjacent coast of the Gulf of Mexico Bureau of American Ethnology, Bull. 43.
- _____. 1946. The Indians of the southeastern U.S. Bureau of Am. Ethnology, Bull. 137.
- Tagatz, M.E. 1968. Biology of the blue crab, Callinectes sapidus Rathbun, in the St. Johns River, Florida. Fishery Bull. 67(1): 17-33.
- Terrebonne Parish Development Board. 1953. Terrebonne Parish resources and facilities. Dept. of Public Works, Planning Div., Baton Rouge, Louisiana.
- Thomas, P.M., Jr., L.J. Campbell and T.D. Montagne. 1977. Sampling strategy in archaeological survey: archaeological reconnaissance in west La. and east Texas: Texoma group strategic petroleum reserve sites. Institute for Maya and New World Research, Report of Investigations No. 1.
- Toth, A. 1977. Early Marksville phases in the lower Mississippi Valley: a study of culture contact dynamics, Ph.D. dissertation, Dept. of Anthropology, Harvard Univ., Cambridge.
- U.S. Army Corps of Engineers. 1981. A feasibility report/environmental impact statement on the Atchafalaya Basin Floodway System, Louisiana. USCOE, New Orleans District, La. 4 Vols.
- U.S. Army Corps of Engineers. 1978. Terrebonne Parish regional sewerage facilities. Draft Environmental Statement. U.S. Army Engineer District, New Orleans. La.
- U.S. Dept. of Commerce. 1980. Computer printouts (April). Bureau of Economic Analysis, Regional Economics Information System.

- U.S. Dept. of the Interior. 1976. A progress report fish, wildlife and related resources Atchafalaya River Basin, Louisiana. U.S. Department of the Interior, Bay St. Louis, Mississippi. 348 pp.
- Usie, L. 1982. Pers. Comm. U.S. Dept. of Commerce, National Oceanic and Atmospheric Admins., National Marine Fisheries Serv., Houma, La.
- Valiela, I., Teal, J.M. and Sass, W. 1975. Production and dynamics of salt marsh vegetation and the effect of experimental treatment with sewage sludge. I. Biomass, production and species composition. *J. Applied Ecol.* 12, 973-981.
- Vansickle, V.R., B.B. Barrett, L.J. Gulick and T.B. Ford. 1976. Barataria Basin: salinity changes and oyster distribution. Louisiana State University, Center for Wetland Resources, Baton Rouge, La. Sea Grant Publ. No. LSU-T-76-002.
- Wallace, J.B., J.R. Webster and W.R. Woodall. 1977. The role of filter feeders in flowing waters. *Arch. Hydrobiol.* 79: 506-532.
- Wass, M.L. and T.D. Wright. 1969. Coastal wetlands of Virginia, interim report to the governor and general assembly. Virginia Institute of Marine Science, Special Report in Applied Marine Science and Ocean Engineering, No. 10, 154 pp.
- Watson, C.C. 1981. A review of the tentatively selected plan for the Atchafalaya Basin Floodway System. Unpubl. report submitted to: Terrebonne Parish Police Jury. Address of author: Water Engineering and Technology, Inc., Shreveport, La.
- Wax, M.U. Borengasser and R.A. Muller. 1978. Barataria Basin: synoptic weather types and environmental responses. Louisiana State University, Center for Wetland Resources, Baton Rouge, La. Sea Grant Publ. No. LSU-T-78-001.
- Weinstein, R.A., E.K. Burden, K.I. Brooks and S.M. Gagliano. 1978. Cultural resource survey of the proposed relocation route of U.S. 90 (LA 3052), Assumption, St. Mary and Terrebonne parishes, La., Coastal Environments, Inc. Baton Rouge.
- _____ and P.G. Rivet. no date. Beau Mire: a late Tchula period site of the Tchefuncte culture; Ascension Parish, La. La. Division of Archaeology and Historic Preserv., Tech. Rept. 1, Baton Rouge.
- Wetzel, R.G. 1969. Factors influencing photosynthesis and excretion of dissolved organic matter by aquatic macrophytes in hardwater lakes. *Verh. Internat. Verein Limnol.* 17, 72-85.
- Wheat, J.B., J.G. Gifford and W.W. Wasley. 1958. Ceramic variety, type cluster, and ceramic system in southwestern pottery analysis. *Am. Antiquity* 24:1.
- White, D.A. Weiss, T.E. and J.M. Trapani. 1978. Productivity and decomposition of the dominant salt marsh plants in Louisiana. *Ecology* 59(4): 751-759.

- Whitney, L.F. and A.B. Underwood. 1952. The raccoon. Practical Science Publ. Co. Orange, Conn. 177 pp.
- Wicker, K., M. DeRouen, D. O'Conner, E. Roberts and J. Watson. 1980. Environmental characterization of Terrebonne Parish: 1955-1978. Coastal Environments, Inc., Baton Rouge, La.
- _____. 1980. Mississippi deltaic region ecological characterization: a habitat mapping study. A user's guide to the habitat maps. U.S. Fish and Wildlife Serv., Office of Biological Services. FWS/OBS-79/07.
- _____ et al. 1980. The Mississippi deltaic plain region habitat mapping study. 464 maps. U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OES-79/07.
- Weigert, R.G., and F.C. Evans. 1964. Primary production and the disappearance of dead vegetation on an old field in southeastern Michigan. Ecology 45: 49-163.
- Wiley, G.R. 1949. Archeology of the Florida gulf coast. Smithsonian Miscellaneous Collections 113, Washington.
- Williams, A.B. 1958. Substrates as a factor in shrimp distribution. Limn. Oceanog., 3: 283-290.
- Zeringue, F.J. 1980. An ecological characterization of the Lac Des Allemands Basin. Louisiana State University, Baton Rouge. Masters thesis. 100 pp.

